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The *Bulletin* serves as a means of communication between the Department of Defense, its authorized agencies, defense contractors and other business interests. It provides guidance to industry concerning official DOD policies, programs and projects and seeks to stimulate thought on the part of the Defense-Industry team in solving problems allied to the defense effort.

Suggestions from industry representatives concerning possible topics for future issues are welcomed and should be forwarded to the Editor at the address shown below.

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IN THIS ISSUE

FEATURES

DEPARTMENTS

Basic research, as symbolized on the cover, is the source of our technological strength. This month, the *Defense Industry Bulletin* explores the subject of basic research at the Defense Department level, and as conducted by the Army, Navy and Air Force.

The Defense Research and Technology Base

[Editor's note: The following is an excerpt from the statement by Dr. John S. Foster Jr., Director of Defense Research and Engineering, on the FY 1970 Defense Research, Development, Test and Evaluation Program, presented on April 30, 1969, before the House of Representatives Committee on the Armed Services. It provides an appropriate preface to articles in this issue discussing organization and functions of the research activities of the Army, Navy and Air Force.]

The superiority of American military technology depends on many critical components—talented people, a commitment by many to excellence, our industrial capacity to apply new technology. But the ultimate source of our technological strength today is the research and technology base so carefully built up over the past 5, 10 and 20 years. In the same way, our future strength can only be ensured by vigorous, balanced investments made now in exploring new ideas. This need is just that simple. Yet the work is often hard to explain and justify. I will try now to give you some sense of the significance of our research and technology base.

Broad Goals of Research and Exploratory Development

The goals of research and exploratory development must be formulated from two perspectives: long-term gain, consistent with the nature and direction of scientific technological progress; and shorter-term matters of concern to our national security. Stated in the jargon of the investment business, we must maintain a basic portfolio of growth securities, devote a small fraction of our resources to high-risk but promising speculative ventures, and maintain a capital reserve of technical competence adequate to cope with unexpected technological threats or opportunities as they arise. Neglecting any one of these could jeopardize national security. The greatest overall security obviously lies in an optimum balancing of available resources. It is difficult to know how precisely when that balance is achieved.

For the long term, we seek to probe the frontiers of defense-relevant science and engineering, to discover and understand new phenomena, to recognize and exploit those which have promise for improved military technology. Thus, we support research in the laboratories of DOD, universities, industries, and the Federal Contract Research Centers. From these laboratories have come radar and rockets, transistors and television, combat radios and computers, sonar and satellites, and a host of indispensable military systems. Because a technical surprise today could unpredictably destabilize the international situation, our program must be broad and carefully diversified to allow us to move quickly in any required direction.

Nature of Soviet Technology

To suggest the character of the technical challenges we may face in the future, I believe it will be helpful to illustrate briefly some of the areas in which we believe the Soviet Union is particularly active. I do not introduce this perspective because of any anxiety that the Soviet Union is, technically, "10 feet tall." Nor do I believe we are on any "technological plateau," as some have argued; the facts show that we are not. But I do want you to understand that the Soviet Union is an advanced and vigorous technical nation, investing proportionately more of its scarce resources in research and development than we are, and presumably getting results from its investment. Except where I indicate otherwise in this discussion, few of the Soviet efforts represent substantially greater capability than we now possess, although in many areas we probably are about even.

The Soviet effort in magnetohydrodynamics is the largest in the world. Two prototype continuous open-cycle electrical generating power plants are now in operation in the USSR and the Soviets are developing a closed-cycle system. The latter could have strategic applications in submarine and in space propulsion.

Dr. John S. Foster Jr.

Although the Soviets have not fully exploited their strong capability in semiconductor research in the past, the use of solid-state devices in the consumer, industrial and military fields is rapidly becoming a reality.

Microelectronics has not been widely applied in the USSR, although progress has been rapid since 1962. Miniaturization has not advanced much beyond the employment of compact transistor circuits and is achieved principally by high-density packaging of discrete components on printed boards. Large-scale use of microelectronics appears to be several years away; its initial use will probably be in large digital computers in 1970–71.

Development of radar antennas has paralleled that of western countries, current emphasis being placed on a wide variety of microwave antennas for general and special uses and on large, multibeam, electronically steerable phased arrays.

The Soviet Union has expended a

massive effort to develop, produce and install active infrared sensory devices. By 1975 low-light-level image intensifiers should be available for widespread use in the Soviet Union.

Since 1962, the Soviet laser program has been expanding and is now second only to the United States in their overall research and development effort. The USSR may be ahead of the United States in the development of high-power, solid-state lasers.

The Soviets will probably continue their underground nuclear tests, just as we will. These tests will allow them to develop improved fission and thermonuclear weapons tailored for special uses and to explore weapon systems vulnerability to nuclear radiation.

There have been and will continue to be strong Soviet efforts to improve the performance—and increase the time between overhaul—of their rotating (turbojet, turbofan) aircraft engines. This emphasis will result in new and improved engines, such as the capability to qualify a Mach 3 cruise turbojet by 1969–70, and lift/cruise and direct-lift engines with very good thrust-to-weight ratios by 1970.

Soviet liquid-propellant rocket engines in some ways are distinctly different from those of the United States, as reflected in larger expansion ratios, higher chamber pressures, different materials of construction and better control of combustion processes. The Soviets have the capability to build and utilize much larger liquid-rocket engines for space purposes than they have heretofore exhibited. For ballistic missiles, no completely new liquid-propellant engine designs are expected before 1972. However, as a result of concerted efforts beginning in 1958, the Soviets are capable of building solid-propellant motors having performance characteristics similar to those of the West.

Soviet capability in materials and manufacturing technology has developed surprisingly fast and is now generally equal—in some instances, superior—to that of the western world. Difficulty in achieving the high standards of quality control necessary for the quantity production of highly precise and highly reliable components appears to limit Soviet production capability at present; however, it is expected that this problem will be solved in the next two or three years. Some of the areas in which the Soviets seem to be advanced are chromium-base alloys for long-time operation at 1,900 degrees to 2,200 degrees F., high-temperature adhesives, high-temperature polymeric coatings, use of glass-reinforced laminates, techniques and machinery for fabricating brittle materials and difficult shapes, and machinery for extruding and forging large metal parts.

Allow me to repeat that these Soviet technological programs have not eliminated our margin of technical superiority in most of our systems. Nevertheless, the range, pace, and apparent quality of their work in the fundamental sciences and applied technology are impressive.

Trends in DOD Research and Technology Base

The past fiscal trends in our research and technology base are shown in Figure 1.

Despite the increasing complexity of defense technology and the increasing costs of carrying on more demanding research and development, support for our overall research and technology base has continued to decline. We reversed the downward trend in the research category in FY 1969, based in part on my special concerns about this activity last year. But the overall trend of our base is still downward, because of both the increased cost of research and development and the continued erosion of exploratory development owing to urgent needs for funding other research and development activities. We continue to see the indicators of significant under funding in this program: an increasing ratio of acceptable proposals to funded proposals; deferral of purchase of needed new research equipment in many academic and industrial research laboratories; layoffs of technicians and postdoctoral research fellows; and too few "new starts" because of the pressing need to continue existing projects.

Continued failure to reverse the trend of this critical part of defense research and development could seriously jeopardize our future national security. Thus, I have requested increases for both areas in FY 1970, including an especially substantial increase for exploratory development. I will discuss each area and give you my recommended funding.

Research

Research Objectives and Policies

Within the broad goals of our research and technology base, the research component works at the frontiers of knowledge in the physical, engineering, environmental, biomedical and behavioral sciences, emphasizing fundamental work relevant to long-range defense needs.

DOD must manage a mission-oriented research base, as must (or should) all of the major agencies. Because the effectiveness of coupling basic science with defense technology is so vital and in many ways so subtle, DOD must recognize and direct responses to scientific and technological opportunities or threats. We could not rely upon an accidental occurrence of this critical function.

Recent Research Accomplishments

New scientific findings continuously emerge from DOD-supported research. Significant contributions have been made by in-house laboratories, industrial laboratories, non-profit institutes, and university research performers. I will give you just a few examples.

Global thunderstorm activity detection.

We are almost totally dependent on the electromagnetic spectrum for communication, detection of enemy activity by various types of sensors, missile guidance, and other military activities. Detailed knowledge of global thunderstorm activity would increase the reliability of our electromagnetic systems. We have found promising new sensors to obtain this global data through recording that spectral component of longest duration in lightning. The technique is being tested on U–2 aircraft and appears to be ideal for continuous surveillance by satellite. It is expected to be available for use within a year.

High-temperature lubricants.

A new technique for the fluorination of organic compounds and graphite has been developed by passing a mixture of fluorine and an inert gas over the surface of the compound to be fluorinated. For example, graphite can be converted to perfluorographite, which has lubricating properties comparable to currently used lubricants at normal operating temperatures

(400 degrees F.) and much superior to them at temperatures in excess of 575 degrees F. They will be especially useful in the bearings and seals of advanced jet engines.

Uultrashort laser pulses.

The range of defense applications of laser technology has been enlarged by recent developments in the production of ultrashort laser pulses. Pulses of less than a millionth of a microsecond in duration have been generated. The much more precise timing and distance measurements, possible with these very short pulses, promise important improvements in optical radar, laser communication systems, rapid optical data processing, and ultra high-speed photography.

These examples typify the thrust of scientific and technological achievements to defense goals.

Before leaving this discussion of specific, rather basic research efforts, I want to illustrate the way in which this work leads to applications. A good illustration comes from the materials sciences, in particular, composite materials. The promise inherent in filamentary materials was originally predicted from independent theoretical studies and independent university research on metallic whiskers. The fundamental objective of this work was to study why theoretical strengths could not be achieved in actual materials. While this work was interesting from a scientific point of view, it could contribute little to the materials used in military applications unless someone identified the connections between the basic scientific findings and DOD needs. Research managers in DOD, having just such a motivation, *i.e.*, that scientific findings can and must be put to practical use, recognized that these discoveries could help solve some military problems.

It was the requirement for stronger, lighter materials that caused the Military Services, as far back as the late 1940s, to make fine filaments, to study their properties, and to conduct research to improve them. Basic and applied research in the Air Force alone (which had the greatest need and interest) reached almost $3.5 million in FY 1966. This pursuit of a promising scientific finding led to an on-going advanced development program which will put composite materials into many Air Force and other military applications with substantial savings in weight, or increase in engine thrust, payload, range, or maneuverability.

Occasionally I am asked whether some of our more basic research could be carried out as effectively under other than DOD sponsorship. It is the kind of evolution that I just illustrated that convinces me the Defense Department must sustain clear and close links to the scientific community.

But then I am asked whether we tend to duplicate the work sponsored by other agencies. I am quite confident that there is essentially no duplication, except where there are distinctly different scientific approaches to solving the same basic problem. Last year, for example, we examined the work being conducted under 10 contracts sponsored by the National Science Foundation in the materials sciences. The total value of these contracts was about $500,000. It was determined that very little, if any, of the contracting work was directly germane to DOD mission objectives but that about 10 percent (or $50,000) could be considered relevant.

Let me give you another example of the coordination process we use to avoid duplication. DOD and NASA have conducted annually a detailed review of all research and exploratory

Trends in Research and Technology Base

($ in millions)

	FY 1964	FY 1965	FY 1966	FY 1967	FY 1968	FY 1969
Research	$ 353	$ 383	$ 389	$ 413	$ 371	$ 406
Exploratory Development	1,158	1,128	1,134	1,042	948	878*
TOTAL	$1,511	$1,511	$1,523	$1,455	$1,319	$1,284*

*The reduction in FY 1969 (compared with FY 1968) includes a $45 million reduction in which these funds were transferred from the Advanced Research Project Agency's exploratory development effort on ballistic missile defense to the Army's advanced development effort on missile defense. The nature of the work supported has not changed in character. Thus, this was essentially an accounting change. FY 1969 funding is, in effect, $923 million, and the total is, in effect, $1,329 million.

Figure 1.

development projects in the biological, medical and life sciences at the individual work-unit level since FY 1965. Methods were developed to compile all related research work by subject matter which is then analyzed by DOD/NASA technical teams. Research efforts that might overlap are identified and subjected to a detailed review, and a joint decision is made on terminating a contract, if appropriate. Out of about 4,000 tasks reviewed recently, there were no more than six cases of even partial overlapping. This procedure has been very effective in assuring that no unwarranted duplication exists, ensuring that each agency has full knowledge of the scope and content of each others' research programs, and aiding the day-to-day coordination between agencies by the biomedical research program managers.

* * * *

Recommended Budget for Research

Following an in-depth review of the various levels and directions of research programs, I am recommending a total of $432 million for FY 1970. This increase provides for 25 new Project THEMIS programs, and for a 4 percent cost of living increase for the rest of the research activity. As I said earlier, this investment is for the future—this is the investment that will determine, in large measure, whether we maintain our technical superiority.

Exploratory Development

I will turn now to exploratory development, the second segment of our research and technology base.

The purpose of exploratory development is to demonstrate the feasibility and applicability of research discoveries to DOD needs. It is also the mechanism we use to ensure that each technological opportunity has a matching military utility, and that feasibility determinations are made in full realization of the anticipated use of the device or component. Thus, before we embark on expensive advanced or engineering developments of any weapon system, we use exploratory development to give us a high degree of confidence in the technical feasibility of the system.

Past studies have shown that new systems that are markedly improved over their predecessors frequently are made possible by the aggregation of many component improvements. This aggregation and eventual proof of feasibility may take as long as 10 years to become operational in a finished system. Thus, we must attempt to predict our military needs in advance, well ahead of firm official requirements. These predicted needs can change in many directions, including changing enemy technical threats. To guard against serious technological surprise, we have a broad exploratory development program to provide a choice when our needs become clearer and our optimum response more firmly defined. This is one of two main reasons why we have thousands of exploratory development projects.

The other main reason for a broad program is that the development of a system to meet one operational goal often leads to an array of many difficult technological problems and projects. Let me illustrate this.

The Vietnamese War has clearly demonstrated the high cost of flying aircraft directly over well-defended targets. For such purposes it is becoming increasingly necessary to deliver tactical ordnance from a stand-off position, *i.e.*, outside the range of the defensive systems. Stand-off ranges of 20 to 30 miles would be adequate today, but longer ranges will be required in a few years. A closer look at this requirement reveals two most demanding sub-requirements. First, since this type of missile is not intended to deliver high-explosive ordnance, it must hit the target within a few feet. Second, since the weapons effect is relatively small, the cost of the system must be low.

Achieving this one new, comparatively straightforward operational capability—stand-off, low-altitude delivery of high-explosive ordnance—has required major improvements in guidance and propulsion. Of these, let me illustrate how the propulsion problem alone fanned out into a range of tasks for new technology.

There are at least three distinctly different types of propulsion systems that had to be explored to achieve the earliest possible capability and, eventually, the highest possible performance. They are first, a pulse-type solid rocket, which appeared to be the most readily available; second, a ramjet with integrated booster; and, third, a high-density solid-fuel ramjet with integrated booster, which appeared to offer the higher performance, the range ultimately desired.

Each of these types, however, involved a whole series of technological problems. For example, to achieve a stop/restart capability in solids, several methods had to be investigated: water quench, variable-area nozzles, secondary gas generators, and inhibiting partitions. Exploratory tests of all of these methods were run and, for this application, inhibiting partitions appeared to be the simplest and most readily achievable. But, to keep the area of the inhibited faces small, the burning rate of the propellant had to be increased which involved the development of new burning rate catalysts and higher chamber pressures. The new catalysts required the development of new liner materials, and the higher chamber pressures raised the erosion of nozzle throats and imposed increased pressure loads. These effects led to the required development of new nozzle materials and new methods of bonding the propellant to the case. In a similar manner, the solid-fuel ramjet posed a whole series of new technological problems. A new grain formulation which would yield a fuel-rich, highly combustible exhaust had to be discovered and developed. Its combustion efficiency had to be measured under simulated ramjet combustor conditions, and an aft inlet had to be worked out for use on a missile maneuvering at high angle of attack.

The point which I wish to make here is that, to achieve this single new capability, it has been necessary to pursue three options, each requiring solutions to a series of technological problems. This is typical of how our exploratory development program evolves. In this case, all of our efforts have paid off, and the solutions obtained in the process have created a background of knowledge applicable not only to air-launched propulsion, but to surface-launched tactical and strategic systems as well. I am confident that, had we tried to achieve this operational capability without the necessary technological base, the consequences would have been a far greater development expense and the serious compromise of system performance.

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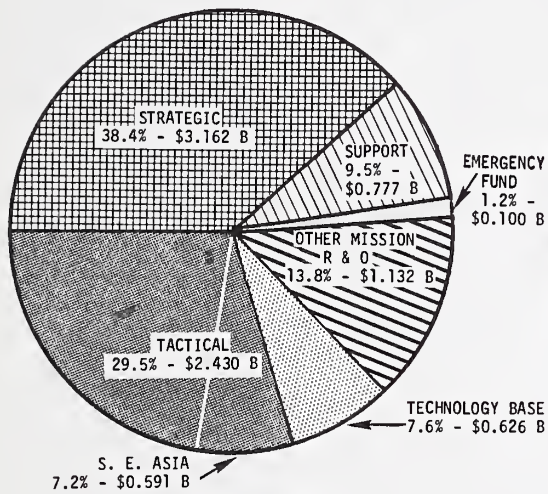
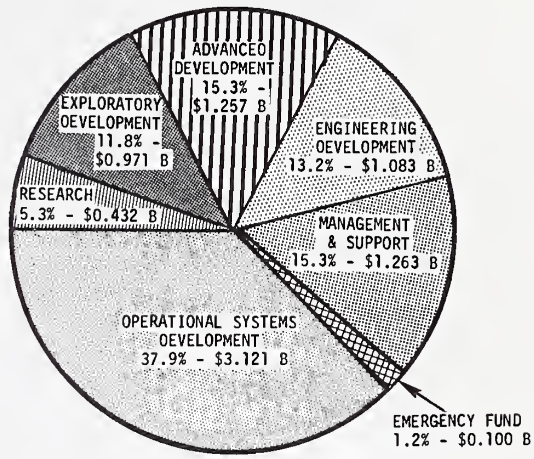
($8.227 Billion)



Mission Distribution



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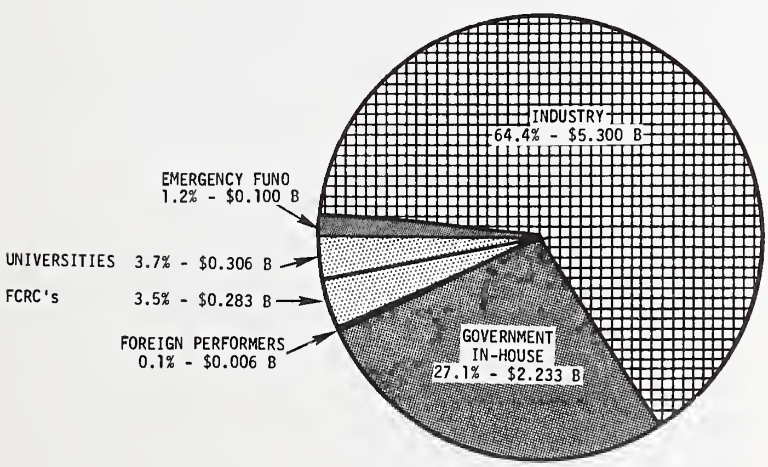


Performer Distribution

Recent Contributions of Exploratory Development

The exploratory developments of the past few years have made many significant contributions to our military capabilities. The three initial conditions that must exist before we embark on any exploratory development project are: first, some understanding of the physical phenomena involved; second, one or more clear concepts about how these physical phenomena can be harnessed to perform some function; and third, really most important, that we see a general need for this function, whether new or improved. I would like to illustrate these points.

During the early operational phases of the Polaris submarines, the Navy recognized the operational advantages of achieving greater depth and speed. Thus, in 1960, the Navy began efforts to develop a higher strength steel for submarine hulls, stronger than the steel then available for Polaris submarines. During the period from 1960 through 1968, the Navy spent about $6 million on exploratory development of high-strength steel.

When the Soviet submarine threat became clear in 1967–1968 and the decision was made to proceed with development of advanced nuclear attack submarines, the technology of the desired steel was sufficiently understood to embark on an advanced development program. This program is timed so that the high-strength steel can be qualified and certified for use on this new class of submarines.

This capsule history brings out an important point. When the development of the new steel was started in 1960, no firm "requirement" existed, but a clear, though generalized need was anticipated. Had we waited for a firm and detailed requirement, the material would not have reached a sufficiently advanced stage of development in time to be used for the advanced nuclear attack submarine.

To complete the history to date by quantifying the effectiveness of the new steel: For ships having substantially the same length, displacement and speed, the maximum operating depth can be greatly increased by using the stronger steel. More advanced steels and titanium alloys, which are now in exploratory development, would enable operation at even greater depths.

Let me say a few words about titanium. The titanium industry is a direct consequence of DOD sponsorship of exploratory development. Starting about 1948, the Army, Navy and Air Force established a substantial coordinated research and development application effort on this metal. The impetus for this work was recognizing the potential of titanium alloys, which have high corrosion resistance, to become the strongest metallic structural materials known in proportion to their weight.

In 1968, the United States produced 33 million pounds of titanum. Titanium alloys are used in both military and civilian aircraft as structural members and in the compressor stages of the engine. Without titanium, the supersonic transport would not be capable of meeting its operational goals. The metal is also to be used in submersibles because of its lightness, strength and corroion resistance. Its corrosion resistance has put it into such civilian applications as food and chemical processing. Uses in the near future will include desalination plants and steam power-generating equipment as well as equipment for the transportation industry. By 1978 it is estimated that 100 million pounds of titanium will be used. Our new aircraft will be able to reach their required performance in part because years ago we stimulated the developments which made titanium alloys available today. DOD has profited, but so have many American industries and our whole national economy.

To return to the main theme, let me give another current example of melding technological opportunity with military need. Our night combat efficiency in Southeast Asia has been spectacularly improved with the introduction of night vision devices. Continuing support for the night-vision exploratory development programs is responsible for this achievement. Direct payoffs from the program, as many of you realize, are the Starlight Scope for individual weapons, a night vision goggle for use by individual soldiers, and night vision devices for crew-served weapons and aircraft, such as thermal night sights for our antitank missile systems and night fire-control system of advanced helicopters.

* * * *

There are other examples of products from exploratory development that have proved highly effective: the antifungal treatment to prevent infection from water immersion, laser-guided weapons, some of the sensors for the instrumented battlefield, an oxygen concentrator to replace LOX for pilots, second-generation night vision devices, foliage-penetration radars, flechette-type weapons, and miniaturized high-reliability fuzes. There are many others, such as ceramic personnel armor, transparent armor, "soft-recoil" artillery weapons with greatly reduced weight, a crashworthy fuel system for UH–1 helicopters, a plasma-deposited tungsten-composite rocket nozzle which will operate uncooled at flame temperatures of 6,500 degrees F., an air-cushion landing system for aircraft, improved binary chemical munitions which do away with storage and shipment hazards, and free-swimming divers attaining 1000-foot depths.

Further enumeration of such examples, valuable and exciting as they are, would become tedious. A catalog of these accomplishments is important, in a sense, because we see clearly what we get from our investment. But what is more important is that, year after year in the past, our research and technology base consistently has given us new opportunities and new options. We must support our technological effort so that, in the future, we will have comparable technical opportunities and choices. For it is in exploratory development that the U. S. technical advantage, the U. S. margin of technical superiority, is strengthened.

Recent Trends

The demands placed on our exploratory development program have increased considerably over the years. Many additional projects are necessary to support the varied technological problems inherent in new, sophisticated weapon systems. Yet, as we face the decreasing level of funding, some necessary programs are being pushed aside or reduced in favor of higher priority efforts. In FY 1964, the exploratory development program was funded at almost $1.2 billion. In FY 1969 it had declined by over 25 percent to $878 million. If, in addition, we take into account the increase in the cost of performing this work, then our actual FY 1969 effort is only

slightly over half of the effort active five years ago.

If this trend continues, we will be forced to reduce our level of effort in projects having even higher relative priority in our program. Our ability to meet known threats will be compromised, and we will lose urgently needed options for potentially needed future developments.

I cannot reemphasize too strongly that we must increase our forward momentum in replenishing the reservoir of science and engineering upon which national security depends. This conviction has been validated so often that it has become our guiding principle in the support of our technology base. The decade of the 1970s will reveal the results of the impressively growing Soviet and Chinese technical programs. We surely do not want to be technologically stagnant so that a slight technological advantage or surprise could have historic implications.

I am aware that some have argued that a large DOD program in exploratory development may be justifiable but so poorly coordinated with other large Federal research and development programs that funds are wasted. In particular, for example, some people have asked whether the coordination with NASA is effective. As I mentioned in discussing the research budget, we try hard to discuss our entire program with NASA in several ways through several mechanisms throughout the year. Last summer for instance, the Secretary of Defense and the Administrator of NASA directed a special series of joint "economy studies." These detailed studies cover a number of common DOD/NASA activities in the space and aeronautics areas directed toward identifying actions which can lead to savings. So far, I am impressed with the progress. While significant near-term savings have not been possible, a number of approaches that could lead to significant long-term savings have been identified. The most promising areas are networks (tracking and data acquisition), launch vehicles, and support operations at the Kennedy Space Center and the Eastern Test Range. . . .

Budget Recommendations

We have reviewed every proposed technology program, have related them to priority defense needs, and have totaled the funds necessary to accomplish the overall program. On this basis, I am recommending that $970.5 million be allocated to exploratory development, compared with $878 million in FY 1969. This will reverse the recent trend, accelerate promising current programs, and permit the start of necessary new programs. I urge you to support this increase.

The Advanced Research Projects Agency

I have already referred in other parts of my statement to recent research and exploratory development in which the Advanced Research Projects Agency (ARPA) has made a major contribution, notably in strategic technology, nuclear monitoring, overseas defense research, and advanced sensors.

Now we should discuss briefly the role of ARPA in our overall research development, test and evaluation (RDT&E) establishment and mention some other ARPA accomplishments. These accomplishments include technical advances as well as several areas of management changes in the transfer of programs to the Military Services.

ARPA, as you know, was established in early 1958 in response to a need for centralized management of selected, high-priority projects. In the past 10 years, ARPA has proved to be extremely effective in handling projects in which feasibility demonstration is essential to DOD, but for which there is no clear Service mission; projects that are multi-Service in nature; and projects that require an especially quick reaction. Because ARPA's primary mission is ensuring DOD against technological surprise, it must search out new fields and ideas, accelerate research and development where surprise could be critical, and bring developments to a stage at which sound decisions can be made on their further exploitation.

It is ARPA's objective to carry programs to a certain stage in research or exploratory development, and then transfer them to an appropriate Service. This past year, the radar and interceptor technology programs of ARPA's ballistic missile defense project (DEFENDER) were transferred to the Army Advanced Ballistic Missile Defense Agency (ABMDA) in consonance with the latter's Nike-X research and development responsibilities. To ensure the successful transfer of the programs and facilities, approximately $45 million in FY 1969 funds and appropriate staff were also transferred. After a review of the strategic research and development field, a Strategic Technology Office was created within ARPA to pursue a broad program of research and development designed to identify, explore and demonstrate advanced concepts and technology that could have major technical impact on the offense/defense balance—hence, on the U.S. strategic capability. One of the major areas assigned to the Strategic Technology Office is laser technology. Selected areas that were inappropriate for transfer to ABMDA were assigned to the Strategic Technology Office to provide the technical core for its new activities. The transfer is judged successful by all concerned.

A new area to be undertaken by the Strategic Technology Office in FY 1970 is research and development in large sea-surface platforms. The objective of this program is to demonstrate the feasibility of large, ultrastable floating platforms adaptable to a wide variety of functions at sea, including forward basing (in addition to, or instead of, foreign-based installations), surveillance, logistics, ballistic missile defense, and tactical command and control.

During FY 1969, ARPA established another new program—advanced engineering. Its major objective is to explore new areas of advanced engineering for selected tactical warfare problems. These problems include the development of quiet aircraft and helicopters, and developing new concepts in small arms. Included in this program's research plans for FY 1970 are the investigation of a low-cost, lightweight flying machine (perhaps less than 50 pounds in weight and $500 in cost) which could be used for individual troop mobility, and a surface-effect vehicle in the 100- to 200-knot class which would have potential in anti-submarine warfare and high-speed patrolling.

Another of ARPA's projects was reoriented in FY 1969. The effort, formerly called Nuclear Test Detection (VELA), now includes programs concerned with nuclear proliferation,

prediction of the location of clandestine nuclear tests, countermeasures to capabilities and techniques previously developed by the VELA program, and diagnostic data on nuclear explosives. These new programs have been entitled "PRIME ARGUS." A substantial phasing down in the older, on-going VELA program concerned primarily with nuclear test detection will take place during FY 1970.

In FY 1970, a Military Geophysics Program will be started under the newly formed Nuclear Monitoring Research Office, which also manages VELA and PRIME ARGUS, to demonstrate the feasibility of countering threats to the national defense posture posed by the modification of the natural environment. The program will try to determine the extent to which underground nuclear explosions can stimulate earthquakes; the extent to which man's non-nuclear, defense-related activities can stimulate earthquakes; and, finally, the feasibility of techniques that might permit control of earthquakes. Because of the great national interest in this field, we will arrange for intra-agency consultation on all major elements of the program.

ARPA has three projects that are funded in the research category: Information Processing Techniques, Behavioral Sciences, and Materials Sciences. In each of these projects, a major portion of the effort is conducted for ARPA by universities. We have attempted to provide these institutions with a funding mode that will permit them to make the required commitments for staff, facilities, students and university funds.

In the past year, ARPA's Information Processing Techniques project has completed research on a computer software system for data management; ADEPT (the operating system) and TDMS (a set of user-oriented data management programs) will permit far more rapid and effective computer operations than were possible in the past. Already in trial use in the National Military Command Center and the Air Force Command Post, ADEPT makes it possible for many users to have simultaneous access to the computer, and incorporates such advances in file organization that requests for computer services which formerly took hours to fill may now be answered in minutes.

In the behavioral sciences area, research is being continued to organize information pertaining to foreign cultures in order that military and civilian advisers become more effective in communicating with people of other nations. For example, a technique known as the Cultural Assimilator has been developed. This technique employs a set of programmed teaching materials on a country's culture and seeks to improve an individual's cultural sensitivity to an area he visits or to which he is assigned. The Cultural Assimilator is proving to be effective in aiding the performance of DOD personnel in a foreign environment. Thailand and Iran are among the countries for which Cultural Assimilators have been prepared.

Recent fundamental research on penetration mechanics supported by ARPA's Materials Sciences project has pointed the way to new approaches that may lead to the capability of providing adequate protection for the infantry soldier with a considerable reduced weight penalty. These research findings are being made available to the Army for exploitation. Recent work in explosive forming technology has resulted in substantial advances in the fabrication of large shapes. For example, single-piece domes are currently being produced by this technique for the Sprint missile.

In FY 1970, the Materials Sciences project will start an intensive investigation of properties of rare earths and other exotic materials, with the expectation that certain of these materials will lead to great improvements in magnetic and semiconducting devices. Effort is continuing to increase the relevance of the fundamental research in the Interdisciplinary Laboratory (IDL) Program to DOD needs. A large number of IDL researchers began regular visits to DOD laboratories during the past year to assist in the solution of DOD materials problems.

ARPA has six projects funded in the exploratory development category: Strategic Technology, Nuclear Monitoring Research, Overseas Defense Research, Advanced Sensors, Advanced Engineering, and Technical Studies. . . .

In 1968, ARPA continued to make quick-response research and development contributions for Vietnam through its Overseas Defense Research and Advanced Sensors projects. To highlight two especially important efforts, ARPA continued its progress in counterinfiltration and intrusion detection technology. At the request of the U.S. Commander in Korea, ARPA undertook a system design study of the infiltration problems facing the Republic of Korea.

In Thailand, ARPA is working as a member of the Country Team carrying on systematic research and development on how to deter insurgency. Every project is approved in advance by the Thai government and by the U.S. Ambassador. With their approval, we work closely with the Thai government. For the past two years, ARPA has conducted a system design and test program. The resulting pilot system designs have been carried through the final phases, and the Thai government is taking over further responsibility. ARPA has also provided technical assistance to the Thai government to develop a boat hull for patrol vessels suitable for the shallow, rocky Thai waterways. The Thai government is now proceeding with the development of the hull entirely on its own.

ARPA's Technical Studies project provides specialized scientific, technical and engineering support to the

ARPA Projects in FY 1970 Budget

($ in millions)

Research	
Materials Sciences	$ 17.3
Behavioral Sciences	5.4
Information Processing	25.9
	$48.6
Exploratory Development	
Strategic Technology	$ 71.7
Nuclear Monitoring	38.5
Overseas Research	29.4
Advanced Sensors	29.5
Advanced Engineering	13.1
Technical Studies	7.3
	$189.5
TOTAL	$238.1

Figure 2.

rest of ARPA and to my office. The effort is generally in the form of short-term investigations of major problems, often of a quick-response nature, covering the state of the art of a given technology, or reviewing alternate solutions to technological problems facing DOD.

Our FY 1970 budget request for ARPA totals $238.1 million. This includes $48.6 million for research and $189.5 million for exploratory development divided among the projects as shown in Figure 2.

Topics of Recent Special Interest

In this section I will discuss some topics that have been of recent special interest to the Congress. For each I will give a short assessment of the situation.

Development Concept Papers

I will discuss the overall policy framework for research and development management in a moment. But first I want to give you a progress report on a new "discipline" for research and development management on major programs. I am quite satisfied with the initial impact of this new discipline which is imposed through Development Concept Papers (DCP).

A DCP is a summary top-management document for the Secretary of Defense which presents the rationale for starting, continuing, or stopping a development program at each critical decision point. It assesses the known risks involved in each decision, along with the full military and economic consequences of the program, and lays out explicit decision-review "thresholds" for key factors, such as technical performance, cost and schedule. In short, a DCP tries to minimize biased "advocacy" points of view and to state clearly all of the known uncertainties involved in major decisions on research and development.

We have had more than a year's experience with this approach. Since late fall 1967, we have prepared 81 draft DCPs. The Secretary of Defense has personally signed 25 involving more than $12 billion in funding over several years. The others were either approved by my office or returned for further work now in progress. In a few cases we are in the second cycle of revising and updating a DCP for the Secretary's review.

While we have found it difficult to prepare a single, succinct, analytic document for the Secretary which contains all of the issues—and all the pros and cons on each issue, the new process is genuinely effective. The work of preparing a DCP is remarkably valuable in itself, because it forces a dialogue—usually rather objective—among all the key people interested in decisions on major research and development programs. To ensure that the system continues to improve within certain ground rules, we are now drafting a DOD directive on the process.

Research and Development Management Policies

For many years and especially during the last few months, there has been much discussion on the management of defense research and development. Some of this discussion and the resulting publicity have been quite critical, pointing to specific cases (past and current) in which our goals apparently were not achieved or in which our management allegedly was not adequate. I want to discuss these issues and problems with you briefly, broadly and candidly, and I will be happy to try to answer any specific questions you may have.

Let me begin by restating the major criticisms. Some have said DOD has no effective ways to control the costs of major development efforts—and the C–5A transport aircraft development and procurement has been singled out to "prove" this charge. Some have said we start programs long before the required technology is available—the SRAM bomber missile development has been used to support this charge. Some have said we agree to unreasonably optimistic schedules for development efforts—the delays encountered in completing development of the Mk–48 torpedoes have been cited as demonstrating this failure. Some have said we do not carry out a sufficient number of competitive prototyping efforts, and for this reason we fail to achieve reliable results in advancing the state of the art—a series of electronics programs during the 1960s has been "analyzed" to "prove" this charge. Finally, some have said we tend to reward the least efficient contractors with follow-on contracts and to grant unreasonably high profits to most contractors.

If none of these charges were in any respect valid, we would simply be the targets of irresponsible criticism. If this were the case, we would not be concerned, although we would have to improve our communications. But the facts show that each criticism contains some element of truth, unfortunately along with a much larger element of misinformation and distortion. Further, the facts show that DOD has been concerned *and active* in solving the management problems revealed in the past. Overall, defense research and development continues to be complex, costly and (most important) central to our national security. Thus, research and development management has been a prime concern of past Secretaries of Defense. While I am primarily and continuously responsible for research and development management, it also holds the first-priority attention of Secretary Laird and Deputy Secretary Packard.

Let me now outline what I regard as the basic issues underlying defense research and development management, and trace briefly the history of changing management approaches.

There are many approaches to acquiring weapons. We can concurrently develop the system in the laboratory and prepare to produce it. We can develop prototypes first so that we can "fly before buying." Or, we can buy items that have been developed at the supplier's risk and are on the shelf.

Over the past 20 years, we have seen different strategies for using these options. These strategies have been shaped as much by the national objectives and priorities then current, as by technical possibilities and management policies. Throughout the 1950s, the Soviets were presenting many challenges and rapid improvements in their strategic nuclear forces and in the conventional arms with which they threatened NATO. The Iron Curtain amplified our uncertainties concerning their objectives and their progress. The rapid and continuing progress in electronics, aircraft, missiles and weapons provided almost unlimited choices and unlimited potential threats. Given these great uncertainties in threat and technology, we had to take risks and pursue multiple and parallel approaches. We could not risk the delays inherent

in the idealized sequence of developing and then testing laboratory models, then developing and testing prototypes, and then building production versions. National objectives dictated concurrent establishment of production facilities in anticipation of the successful development efforts. Letter contracts were awarded before specifications were fully completed. Competition for programs often could be judged only by evaluating broad technical approaches and organizational competence. Compensation was based on costs.

The management consequences of these approaches were generally well understood from the beginning. However, by the 1960s, the results and shortcomings were beginning to emerge.

For example, a Harvard study, in 1962, carefully examined the development of a number of major systems: five air defense missile systems, one candidate ABM system, three supersonic aircraft, and three ballistic missile systems. The study concluded:

- All but one of these systems became operational and satisfied the goals that had evolved during the development of the programs.
- The systems required development times on the average at least a third greater than the initial schedule—in several cases, twice as long.
- The systems required increased development funding averaging three times more than the initial estimates —in one case, seven times greater.

By the 1960s, Government and industry had learned a great deal about the development of major systems. Moreover, the successes of the programs of the 1950s gave us a position of clear strategic superiority that permitted a change in the urgency and character of national objectives. We were, therefore, in a position to stress a much more deliberate approach to each phase of exploration and acquisition.

Our purpose was to reduce the costs to the Government of major systems acquisition. As you know, the only way to reduce cost without reducing profit is to reduce the risks and cost of manufacture. Therefore, we introduced the philosophy and procedures of concept formulation and contract definition. With this philosophy, new emphasis was placed on thorough reviews of need, feasibility, performance, schedules and costs. Before a major development could be started, DOD insisted on a demonstration that technology was available and on an explicit analysis of precisely what was expected from the investment. When it was decided to acquire a new system, an attempt was made to achieve fixed-price competitive contracts wherever possible.

Concept formulation defines the mission and performance goals of the new system, after a thorough evaluation of the costs of alternative means of satisfying the military requirements. It examines many technical alternatives to select the best technical approach. It seeks to ensure that the effort has reached a point where the needed technology is available and proved, so that no further substantial experimental effort will be required. Concept formulation analyzes the estimated cost, effectiveness and schedule for development of the proposed system to ensure that it compares favorably with all other similar and competing systems.

After all advanced development work is completed, we start contract definition. It is a competitive process designed to verify the completion of concept formulation and to establish realistic, firm management plans. Contract definition culminates in a signed contract, based on the expectation that the system will be produced and go into the operational inventory.

Several major weapon system developments have now been carried through using the program management philosophy and procedures formulated in the early 1960s. Some of these systems will shortly be entering the inventory. It is, therefore, timely to call for a deliberate examination of the results of that philosophy and to extract the lessons in our recent experience. Any management approach tends to be evaluated more by its failures than by its successes. Each of us has impression of the impact of concept formulation and contract definition. I would like to outline our tentative views on the experience of the 1960s.

Our reviews are not yet complete. Cost overruns, schedule slippages, and drifting concepts are still with us. However, it is clear that the systematic application of concept formulation and contract definition *has* resulted in a significant reduction in cost overruns and schedule slippages.

Typical increases in actual system costs have been on the order of less than twice our initial estimates rather than three to seven times greater, as documented in past studies. Often these overruns have seemed larger to you and to the public because the costs publicized originally were the minimum target and did not include recognized incentives and contingencies. In short, we believe cost controls have, in fact, improved. Most increases in cost recently have been the result of an explicit decision to develop a better product using newly proved technology.

Representative delays in introducing operational systems into the inventory, over the dates scheduled at the time of contract definition, appear to be reduced from the delays common during the 1950s. Systems concepts and specifications also seem to be drifting much less from contract definition to deployment than was true for the major systems developed in the 1950s.

This system works best where only straightforward engineering efforts are needed after the decision to enter production. When we simultaneously set a schedule for production while complex and risky development remains to be accomplished, we usually find that we are forced into a concurrency of production and development that compounds our problems. Unfortunately, in too many cases, the desire for a fixed-price contract before the risks have been reduced has placed a dangerous premium on optimism. On occasion, it has strained the technical integrity of both Government and industry.

We have learned that paper design studies, and even extensive analysis and simulation, are essential. However, studies alone cannot always produce an adequate basis for selecting an effective design and laying out achievable schedules, performance and cost. In some cases it is essential that we reduce critical subassemblies or components to hardware, often on a competitive basis, in order to gain adequate assurance of feasibility and design stability. Where the system integration is itself a major source of risk, complete prototypes may be mandatory. Where development costs are small in comparison with acquisition and operating costs, the added costs of competition in hardware may well pay off in total economy. In general, where the total research and development cost represents only a few percent of the total systems cost, competitive prototyping is wise; and

we will continue to follow this practice, perhaps in more situations.

In general, the key to sound defense research and development management is deceptively simple: Our objectives on each program and the way we choose to manage it must be clearly and explicitly stated and then fully debated, especially on the largest programs. We must assess deliberately the threat we face, the national goals, the urgency of solution, the status of the concept and technology, the capabilities of industry, the options avaliable, the costs, and the competing national priorities.

It is a major objective of the new Administration to review our experience and policies on research and development management, and to make sure we benefit from the wisdom we can collectively bring to bear on this subject. We must bring the perspectives of industry, Government and science into new reviews of the experience in the 1960s. We have, therefore, started major reviews by all appropriate senior military and civilian officials of DOD and by major independent advisory groups.

In particular, we have started work by independent analysts and managers from the Defense Industry Advisory Council and the Defense Science Board which advise the Office of the Secretary of Defense. We have also begun detailed supporting assessments which should be completed by this summer. We expect to make any changes in our management practices shown to be needed.

I hope it is now clear that we are aware of the trends and the deficiencies in defense research and development management. Frankly, I believe we have made substantial improvements. We can and will improve it further. I welcome your suggestions on areas which, in your judgment, require special emphasis.

* * * *

Security Policy on Technical Information

Questions have been raised during the past year about what some consider to be the large volume of valuable but unclassified U.S. military technology disclosed in open publications and, thus, made freely available to potential enemies. The Defense Department fully appreciates this concern to make sure that information requiring protection in the interests of national defense and foreign policy is adequately safeguarded.

Thousands of DOD scientific and technical personnel must determine each day what specific information needs protection and what does not. The basic dilemma in these decisions is, on one hand, to encourage the maximum interchange of technical information within the scientific and technical community of the Free World for our own benefit and yet, on the other hand, to minimize any free technical assistance to countries whose interests may not coincide with ours.

I believe there is general agreement that the single best method of protecting important military technical information is the use of proper security classification. As a general requirement within the DOD, information—and here I am quoting the formal definition—"the unauthorized disclosure of which could be prejudicial to the defense interests of the Nation" must be classified. We have what I consider to be a solid policy to provide technical classification guidance to personnel at all levels within DOD to help them make the decisions on classification.

You must understand that the U.S. technical community depends heavily and thrives upon the process of open debate. Without debate in most critical areas of defense research and development, our current technical superiority would be jeopardized, just as surely as it would be if classified information were compromised.

Nevertheless, because of our continuing concern that DOD policies and practices do the best possible job of safeguarding technical information, we have been reevaluating all directives and procedures concerning this responsibility. The purposes of this reevaluation are to ensure, first, that the intent of Congress as expressed in relevant statutes is fulfilled; second, that procedures for identifying and safeguarding information that requires control are effective and as simple in application as possible; and, third, that the public and the scientific and technical community have free access to all information that does not qualify for protection under security directives or under other criteria established by law. This reevaluation is currently in progress.

In-House Laboratories

We have 80 in-house laboratories spending about $1.8 billion in RDT&E funds, split about equally between our in-house projects and the contracts managed by in-house technical staff.

Changing Role and Structure.

In the past, we have had many individual laboratories but no effective system for integrating them within DOD in terms of major problem areas. Our organization has been fragmented along relatively narrow technological areas and, as military needs arose, few organizations were capable of examining the total problem. Thus, we have placed emphasis for several years on building larger aggregations with broader responsibilities, a broader view of problems, and with the range of specialized competence to solve each subproblem.

As examples, within the past two years we have closed three smaller laboratories and have consolidated 16 others into 6. The Army is now planning to consolidate 14 small activities concerned with research and development on nuclear effects into 4 larger groupings, as a first step toward a single "Nuclear Effects Research Center."

These new arrangements have permitted the laboratories to play a more important role in critical systems efforts, such as threat analysis and development of requirements; planning for future weapons; the assessment of the vulnerability of proposed major systems; coupling across the entire research and development cycle; and quick-reaction support for operational forces.

There are many cases which illustrate the importance of having effective in-house laboratories. I will mention one recent example from each Military Department.

- The tragic loss of the nuclear-powered attack submarine Scorpion led to a massive search by more than 40 ships and 6,000 men. After the initial search effort, the primary follow-up work fell to the USNS Mitzar and scientists and engineers of Navy laboratories. For nearly five months this team conducted a painstaking and arduous search which was finally successful. The success of this extraordinary task gives hope of determining why the Scorpion was lost.

Further, it is a major contribution to the Navy's programs in improved deep ocean search methods.

• An Air Force laboratory, during an exploratory development program, demonstrated an entirely new flight control system. The "fly-by-wire" flight control uses electrical wires between the pilot's control column and the control surface actuator, replacing the complicated mechanical linkage system now used in all aircraft. The system has been demonstrated in a B–47 flight test aircraft and shown to be technically feasible. This type of flight control system can reduce aircraft vulnerability as much as 50 percent, depending upon the type of aircraft and system configuration. It has been estimated that for the CH–46 and CH–47 helicopter a weight savings in the flight control system of 77 percent and 86 percent, respectively, would be realized by using fly-by-wire. Efforts are now being made to combine this development with another current development on integrated servo actuator packages for application to the F–15 aircraft. The new technique represents the first basic change to flight control systems since the days of early aircraft.

• Fires have been the biggest cause of death in helicopter crashes in Vietnam. Army laboratories have developed two approaches to reduce or eliminate this hazard. In the past year they have successfully developed a crashworthy fuel system for the UH–1 aircraft and an emulsified fuel which shows considerable promise. The crashworthy system consists of an improved ballistic self-sealing material for the fuel tanks, along with breakaway fuel lines that seal when the aircraft crashes. This system is expected to reduce fire fatalities by approximately 70 percent. By preventing rupture of the fuel systems upon impact, crashes that are survivable should not result in impact fires. These fuel systems will allow crewmen and passengers time to escape from the wreckage. First production UH–1 aircraft and retrofit kits will be produced and delivered in late FY 1970.

Environment for Quality and Productivity.

One of our key objectives for the in-house laboratories is to provide a degree of administrative flexibility equivalent to that of progressive industrial research and development organizations. To try to reach this goal I have had conscientious and sustained assistance from the Civil Service Commission. We have modified certain controls and regulations to meet the special needs of research and development organizations. . . .

We are providing the laboratory manager with the administrative tools to integrate his resources of people, program funds, facilities and equipment. Frankly, today this obviously desirable integration is extremely cumbersome. So we have taken a number of important steps to improve the situation:

• We have taken actions designed to solve 90 percent of the key 42 management problems identified last year in areas such as recruitment, career development and training, personnel mobility, and compensation. However, the manpower controls required by last year's Revenue and Expenditure Control Act (Public Law 90–364) have inhibited our ability to deal with a number of these problems as rapidly as we intended.

• We are planning a two-year experiment to test the hypothesis that the utilization of fiscal controls without numerical manpower controls is a better way to manage the laboratories. This experiment is based upon our view that the traditional numerical ceilings of manpower, imposed *in addition to* fiscal controls, inhibit the laboratories' ability to integrate manpower, dollars, facilities and work load. The Bureau of the Budget supports this experiment.

• The broader application of recent authority to match the salary offers of competitors has permitted DOD laboratories to become more competitive in recruitment. We have improved our ability to attract first-class people into leadership positions, by more rapid promotion and by infusion of new personnel drawn from industry and universities.

• A number of our new weapon centers, which I discussed last year, are operational, and their initial effectiveness validates the concept. Next year we expect to establish at least two more such centers.

• Greater fiscal flexibility has been needed for some time in managing exploratory development in the laboratories to meet new technical opportunities and to respond to urgent operational priorities. The Air Force now has achieved this with a single budget line item per laboratory. The Navy is restructuring its FY 1970 program to permit greater "block funding" to its laboratories. The Army is conducting a two-year experiment on single line item funding for three laboratories.

• Steps have been taken to facilitate the mobility of research and development personnel. The Navy has adopted a single job description for its principal laboratory technical directors, which will permit broader ranging assignments for incumbents. We hope this pattern will be adopted by the Army and Air Force.

• Finally, we have on many occasions encouraged our laboratories to contribute their specialized resources, on a selective basis recognizing DOD priorities, to solving the problems of other Federal agencies, such as law enforcement with the Department of Justice, housing with the Department of Housing and Urban Development, and air traffic control with the Federal Aviation Agency.

My overall assessment is that we have made some clear progress along well conceived lines, yet much remains to be done.

Federal Contract Research Centers

* * * *

This year I would like to present a few general points in our recent thinking about the Federal Contract Research Centers (FCRCs).

First, we are again emphasizing an extremely careful and comprehensive review of the programs assigned to each FCRC. My staff and I now regularly discuss the pertinent critical defense problems faced by the Defense Department with key executives of the FCRCs and with representatives of their military department sponsors. As a result of these discussion, I believe we can have even greater confidence that their programs have significant bearing and direct impact on solving our crucial problems. . . .

Second, we have reconsidered recently an issue which has been brought up from time to time for several years—whether or not these primarily DOD-sponsored organizations should be permitted or even encouraged to apply selectively their specialized capabilities to major domestic problems, such as transportation, urban redevelopment, housing and medical services. We have concluded that when an FCRC has capa-

bilities suitable to a non-defense client, it should be permitted to undertake non-defense work. In short, we believe DOD has developed in the FCRCs a "national resource" which should be used as national priorities dictate, consistent with our needs in the national security area. Thus I have begun discussions with other parts of the Federal Government and with the FCRCs to introduce this concept of "selective diversification." I must add, however, that we do *not* intend to fund programs designed to solve domestic problems, nor do we intend to act as a permanent "middle man" in administering any such programs. Similarly, we do not intend to reduce or dilute our DOD funding to FCRCs for national security work, nor do we expect the FCRCs to reduce or delimit their contributions to defense needs.

Finally, I want to outline our current thinking on the broadest of policy issues related to the FCRC—the continuing need for their sponsorship and possible changes in their funding and functions.

In my testimony last year, I summarized our basic goals and needs for the capabilities represented by the FCRCs. Those goals and needs are still valid. We have received excellent services from these organizations, and we still do. Their services are, in fact, perhaps more critical today than ever before simply because, as defense problems grow more complex, we need as many experienced and objective analysts, designers and managers as we can get. But certain changes have occurred during the past few years that will require continuing consideration of how we gain these services.

One important change, for example, is that civil service pay scales will reach approximate "comparability" with FCRC salary scales during FY 1970. This again raises the issue of whether we should study the possible advantages of transforming any of the current FCRCs into government institutes or laboratories. We understand that the possible advantages of government institutes are to be studied by the Bureau of the Budget on the recommendation of the General Accounting Office. We will of course cooperate in this study.

Another change is the increasing number of industrial and nonprofit groups which have capabilities similar, but rarely equivalent, to those of the FCRCs. This raises the possibility of introducing somewhat more competition into the procurement of some of the services traditionally provided only or largely by FCRCs. However, the funding limitations on the FCRCs largely insure that their sponsors do not ask them to undertake tasks which can be accomplished elsewhere.

Another significant factor which I have already mentioned is the increasing interest by several FCRCs in taking work from non-DOD agencies, both because this work is challenging, and because such work provides an opportunity for professional and corporate growth not possible with the funding available during the past five years. Such "diversification" holds the promise, as I mentioned earlier, of helping the country solve some of its urgent domestic problems. But the process of diversification could lead the management of some FCRCs to consider moving out of the sponsored status and becoming an independent profit and nonprofit group. The choice, thus, is not entirely ours.

These changes sharpen old issues and raise a few new ones. Yet above all else they reenforce our awareness of the marked differences among the individual FCRCs, all of which were created to solve some specific problem which could not be solved as well at the time in any other way. Some are affiliated with universities and are highly specialized in a few research and development areas. Others are strongly hardware oriented and exclusively coupled to major development programs in the Military Departments. A few are broad gauged and policy oriented, potentially capable of contributing to many national goals beyond DOD. Thus, it is difficult to make valid generalizations about them as a class.

Because of these changes, and because of the diversity of the factors involved, we intend to stay very close to all of the management questions regarding the FCRCs during the next year.

Army Research Office

Combat Superiority Aim of Army Research Program

Colonel William J. Lynch, USA

Today's advanced society has benefited from many technological advances pioneered in the research and development programs of the U.S. Army. Among these advances are computers, dehydrated foods, and major medical breakthroughs. Although Army research is not conducted to directly benefit the civilian portion of our population, the public has received many spin-offs. Army research and development is conducted to insure that militarily necessary research will be done.

This article briefly describes Army research, as opposed to development, some of the results, and some aspects of research management.

To put things into perspective at the outset, a short look at the organization which manages Army research is appropriate.

In the Army the Chief of Research and Development, Lieutenant General Austin W. Betts, accomplishes his mission through four directors:

- Director of Army Research (with which this article is concerned).
- Director of Plans and Programs, responsible for budgetary aspects and research and development planning.
- Director of Developments, responsible for hardware development from rifles to aircraft.
- Director of Missiles and Space, responsible for air defense weapons such as the Nike X and space projects, and nuclear, chemical and biological developments.

The Director of Army Research exercises general staff supervision of the research program of the Army; nearly half of the exploratory development; development and test of meteorological material and electron devices;

the Army medical research, development, test and evaluation (RDT&E) program; and the Army behavioral and social science program. Research in the atomic energy field is assigned to the Missiles and Space Directorate.

The Research Directorate also participates in the formulation of plans and programs in assigned areas of Army research and development. In its assigned areas of research and advanced technology, the directorate provides a general staff element responsive to the Assistant Secretary of the Army (Research and Development) and to the Chief of Research and Development, and in their relations of a scientific and technological nature with the Office of the Director, Defense Research and Engineering (ODDR&E), the Navy, Air Force, and the general scientific community. In addition, the Research Directorate provides a scientific analysis and evaluation capability for the Office of the Chief of Research and Development (OCRD) in those areas of research and advanced technology assigned to the Director of Army Research.

The Research Directorate is responsible for:

- General support and stimulation of science and technology for the Army.
- Monitoring Army science information activities.
- Preparation of the annual Army Long-Range Technological Forecast.
- Planning and programming for, and supervising the execution of the Army-wide portion of the research and development program.

The director supervises and coordinates the operations of four Federal Contract Research Centers:

- Research Analysis Corp.
- Human Resources Research Office.
- Center for Research and Social Systems.
- Army Mathematics Research Center.

Assistance is given by the Research Directorate to the Development and the Missiles and Space Directorates of OCRD by providing analyses and assessments on the application of advanced techniques and concepts to the solutions of problems. It also provides staff supervision and prepares policy and administrative procedures for execution of the program assigned to the Army by the Advanced Research Projects Agency of ODDR&E.

The Army Research Office

The Army Research Office (ARO) is the largest of seven field activities of the Research Directorate.[1]

Figure 1 shows the internal organization of ARO. A small office provides administrative and logistical support. Two offices, Plans and Programs, provide staff support. There are six scientific and technical divisions. Civilian scientists and technically trained military officers perform an unique function of scientific support for the whole Army staff. They provide a consulting capability in many disciplines of interest to the Army, as well as liaison and coordination with other Federal agencies, and industrial and academic institutions. Consultants have been furnished for such diverse projects as investigating safety aspects of the use of lasers, and the utilization of information processing, storage and retrieval.

As the executive agent of the Directorate of Research, ARO awards and administers research contracts and grants in selected areas. The following is breakdown of the overall Army FY 1969 RDT&E program by category and shows the portion monitored by ARO (dollar amounts are in millions):

	Total RDT&E	ARO Monitored
Research	$ 94.3	$ 94.3
Exploratory Development	238.4	112.4
Advanced Development	371.7	13.9
Engineering Development	151.6	5.5
Management and Support	266.3	17.9
Operational System Development	543.5	—
Total	$1,624.1	$237.6

[1] *The other field activities of the Army Research Directorate which execute portions of the RDT&E program are: the Behavioral Science Research Laboratory, Rosslyn, Va.; the Army Research Office, Durham, N.C.; the Army Research Office, Europe, Frankfort, Germany; the Army Research Office Latin America, a portion of the Defense Research Office, Rio de Janeiro, Brazil; the Army Research Office Far East, Tokyo, Japan; and the Operations Research Advisory Group, located at the Research Analysis Corp. in McLean, Va., which has no program execution responsibility.*

As indicated in the preceding table, ARO monitors all of the research category, and nearly half of the exploratory development category. The definition of exploratory development has been broadened in recent years, and can best be described as applied research rather than development. The remainder of the exploratory development category is monitored by the Developments Directorate and the Missiles and Space Directorate of OCRD.

ARO also monitors small portions of advanced development, engineering development, and management and support categories. In advanced development and engineering development, the effort is directed primarily toward therapeutic development and general combat support. The major effort in the management and support category is concentrated on studies and analyses directed toward developing analytical methodolgy for operational and research and development planning.

Colonel William J. Lynch, USA, is Assistant Director of Army Research, Office of the Chief of Research and Development, and Commander of the U.S. Army Research Office. His experience includes command of the 739th Nike Battalion, Boston; and staff assignments in the Advanced Research Projects Agency, and as Deputy Chief of Staff, U.S. Army Hawaii. He holds a B.S. in mechanical engineering from Tufts College and an M.S. from New York University Guggenheim School of Aeronautical Engineering.

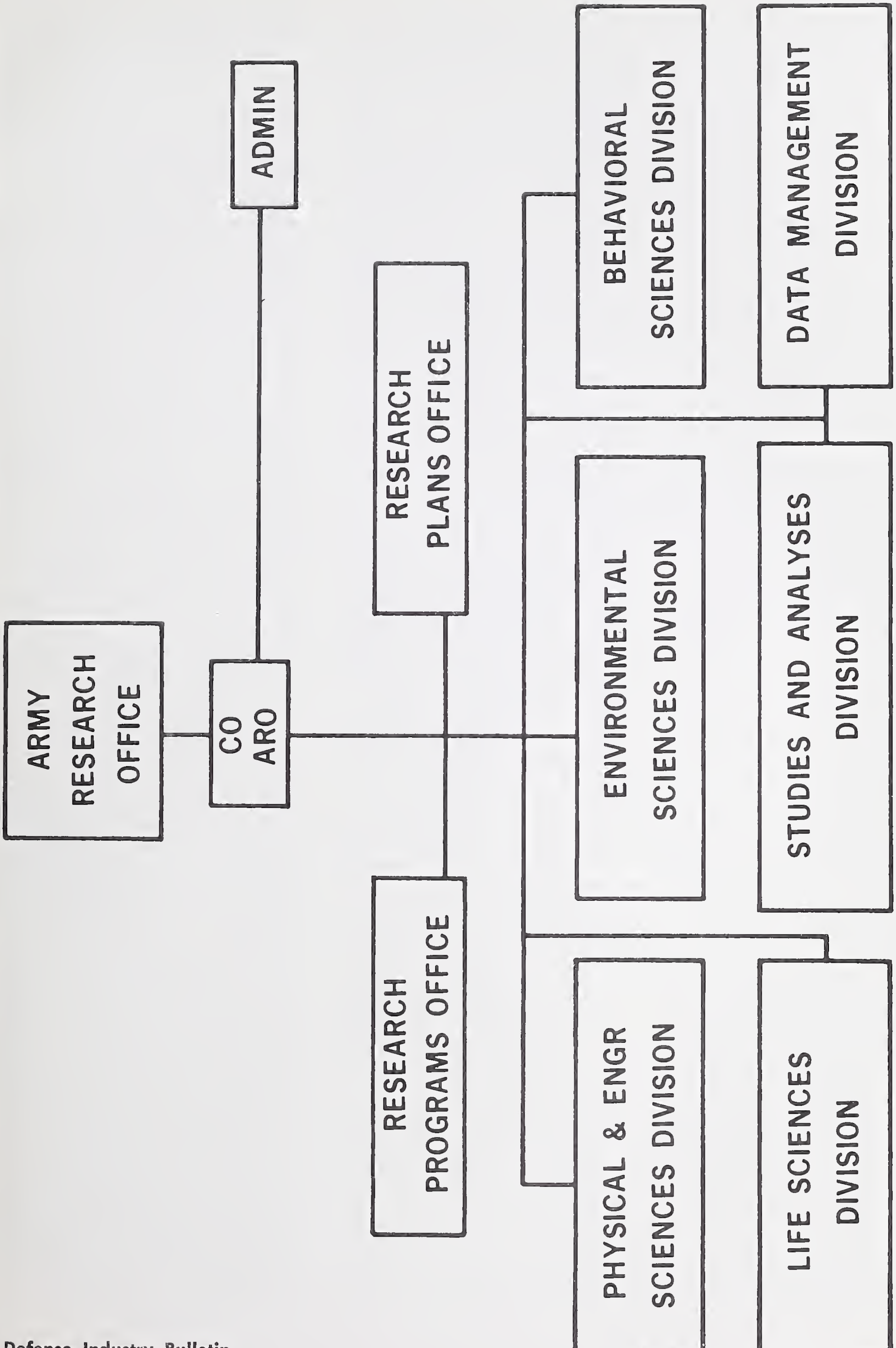

ARMY RESEARCH OFFICE
CO ARO
ADMIN
RESEARCH PLANS OFFICE
RESEARCH PROGRAMS OFFICE
BEHAVIORAL SCIENCES DIVISION
DATA MANAGEMENT DIVISION
ENVIRONMENTAL SCIENCES DIVISION
STUDIES AND ANALYSES DIVISION
PHYSICAL & ENGR SCIENCES DIVISION
LIFE SCIENCES DIVISION

FIGURE 1

Thus ARO has two distinct functions. First, as a general staff element of OCRD, it monitors the total research program and part of the exploratory development program preformed by the eight developing agencies of the Army. Second, as one of these eight developing agencies, ARO also executes part of the program it monitors. In addition, ARO serves as the contact point with the civilian scientific community. In addition to ARO, the other seven developing agencies in the Army are:

- Army Materiel Command
- Office of the Surgeon General
- Army Combat Developments Command
- Office of the Chief of Engineers
- Army Security Agency
- Advanced Ballistic Missile Defense Agency
- Safeguard Systems Office

ARO handles funds for a number of other organizations: the Limited War Laboratory at Aberdeen, Md.; the five Human Resources Research Units at Forts Benning (Ga.), Knox (Ky.), Bliss (Tex.), Rucker (Ala.), and the Presidio of Monterey (Calif.); and three Standardization Groups in Australia, Canada and the United Kingdom.

The $237 million plus monitored by ARO amounts to over 14 percent of the total Army RDT&E budget. Army research now includes over 3,000 tasks in the life, physical, environmental, social and other allied disciplines. The tasks are performed by 60 Army laboratories, approximately 225 universities and colleges, 161 non-profit institutions, and over 300 private firms. About 60 percent of this effort is done by the Army inhouse; the remainder is performed by outside agencies.

The figures cited do not show the breadth of the Army's involvement with science and technology due to the diversity of its needs. This is particularly true as the Army faces the problems of the Cold War, where it finds itself engaged in a type of war calling for knowledge and concepts heretofore unknown. Unlike the sailor and the airman, the soldier finds himself immersed, as in Vietnam, in the total environment of the enemy—psychologically, socially, culturally, politically, and in armed conflict.

Basic Research

The ultimate objective of Army research is to assure that the development of new weapon systems, equipment and operational capabilities for the Army is qualitatively superior to that of any potential enemy, in any environment, and under all conflict conditions. In essence, Army research is ultimately "requirements" oriented. However, one must remember that the end product of *basic* research, new knowledge or science, remains dormant until *applied* research and development either converts it into a piece of new equipment in the hands of the troops, or satisfies a non-material requirement. Examples of the latter might include a more efficient training procedure, a more effective immunization technique, or possibly improved methods for countering low-level conflict in developing countries.

Basic research tries to look into the future for as much as 20 years. The Army is particularly aware of the need for this basic research and continues to support it to the limit of available funding. It is the key to future developments—to the realization of new concepts and designs just over the horizon. In the research area, the Army is "scientifically" oriented, as opposed to "requirements" oriented. The purpose is to increase knowledge of natural phenomena, of the environment, and of problem solving in the physical, behavioral and social sciences, having in mind only broad, long-term military needs. Research in science is fundamental to the Army follow-on development effort because most technological advances are rooted in this basic research. From this point on, research in science becomes more directly oriented toward the Army's operational requirements.

As might be expected, basic research is organized along lines of fundamental science.

The most significant recent impacts upon the level and direction of the Army research program have come from declining funding trends and the war in Vietnam.

Funding for Army research, adjusted by a 5 percent a year cost of living increase, is about 30 percent lower in FY 1969 than the peak year of FY 1965. Distribution of funds for basic research in FY 1969 is (in millions):

Behavioral and Social Sciences	$ 1.4
Life Sciences	22.1
Environmental Sciences	6.1
Engineering Sciences	25.9
Physical Sciences	15.5
University Program and Joint Services Electronic Program	10.6
In-house Laboratory Independent Research Program	11.6

Funds for the In-house Laboratory Independent Research Program are used for research at the various laboratory directors' discretion. The intent is to give individual Army research personnel the means to increase their competence while promoting a vigorous internal research program.

A recent addition to the Army research activity is an experimental university program named Project THEMIS, started as a result of the President's request in 1965 that all agencies contribute to building new academic centers of excellence. This project has the goal of increasing the number of education institutions capable of performing quality research and, thereby, increasing the diversity of scientific inquiry. Under this approach, inter-disciplinary, university-administered programs are established to perform research in specialized areas relevant to defense missions. To date, 92 programs at 66 universities in 40 states have been selected for participation, with the Army monitoring 29 programs.

Exploratory Development

The second major category of the Army research and development program is exploratory development. The key distinction here is the increasing orientation toward specific military problems. As in basic research, control is exercised largely by "level of effort" funding in the various fields working toward solving individual problems.

The exploratory development program is organized into 31 program elements, 22 of which have all or part of the projects monitored by the Army Research Office. The effort is organized into functional or broad technological areas such as avionics, ground surveillance, target acquisition, or missile propulsion.

The decrease in actual level of effort in exploratory development was even greater than for research. Dr. John S. Foster Jr., Director, Defense Research and Engineering, in Congressional testimony indicated that the adjusted level for exploratory development in FY 1968 was equivalent to slightly more than half the

level in FY 1964. He specifically cited avionics, data processing, electron devices, communications and radar as areas with significant under-funding, and he argued that substantially greater funding was needed.

During this same period of reduced effort, the impact of the Vietnamese war insured that certain more immediately relevant requirements received greater emphasis. The normal payoff period for research and exploratory development work has been estimated as 5 to 20 years. Where possible, the research and development community has attempted to shorten the normal cycles by accelerating programs directed toward the requirements for jungle and guerilla warfare in Southeast Asia.

A partial list of such priority military areas would include:

- High strength, lightweight materials.
- Lightweight, transparent armor.
- Dust palliative to minimize helicopter damage.
- Surveillance, including personnel and tunnel.
- Lightweight, durable batteries.
- Silent power sources (fuel cells).

In general, these problem areas arise from increased emphasis on air and ground mobility, and the need to operate against an elusive enemy under difficult conditions.

Payoff of Army Research Program

Touching briefly on some accomplishments of the Army research program, as opposed to development, there have been many somewhat intangible results in mathematics from the Army Mathematics Center, various laboratories and contractors, and in such things as basic chemistry, metallurgy, crystallography, etc., where the application is not direct or apparent.

Concrete examples can be given, however, and some of the most important, with very early payoff, have occurred in the areas monitored by the Behavioral Sciences Division.

Significant accomplishments of the Human Resources Research Office (HumRRO) include:

- A short automated Vietnamese language course for military advisors.
- Improved models of training programs for electronic technicians.
- Improved combat training for the infantryman and for leaders of small infantry units.
- Aircraft recognition training.
- Leadership training programs for non-commissioned officers and for those at senior levels of command.
- Methods and techniques for improving the output of ROTC graduates, including establishment of requirements for the ROTC military science curriculum.
- Background information on the learning capabilities of personnel in lower mental categories.

Many of these have resulted in appreciably shortened training time and school courses.

The Center for Research in Social Systems (CRESS) pursues a program of research developed along four major lines of inquiry:

- **Cross-cultural influence and interaction, including military psychological operations and analyses of foreign cultures.** Of importance has been a series of 26 country studies, known as Intercultural Communications Guides. A basic research task has developed the Associative Group Analysis Technique as a means of improving cross-cultural communications. Other studies have developed a systems analysis approach to the subject of psychological operations, and have analyzed U.S. Army requirement for psychological operations on a world-wide basis.
- **Dynamics of behavior in revolutionary situations.** Studies have been produced dealing with the communist insurgent infrastructure in Vietnam, problems in internal security in insurgent situations, and a systematic and comprehensive analysis of over 50 specific historical internal conflict situations in the 20th century.
- **Military assistance programming and civic action.** Investigations have been made on the role of the military establishment in developing nations, the effects of specific civic action programs, and the military advisory effort conducted by the U.S. Army in Vietnam and other areas.
- **Information management.** This area is represented by an information center devoted to the social sciences, the Cultural Information Analysis Center (CINFAC). This center was established in July 1964 to provide an extensive informational base and analytical expertise on the problems of internal defense, socioeconomic development, and rapid social and cultural change. CINFAC services a wide variety of government agencies and industries, and complements and supplements the research efforts of the parent organization, CRESS. CINFAC alone has provided over 1,000 responses to qualified users in its four-year existence.

Other important contributions have been made in these areas by the Human Engineering Laboratories at Aberdeen, Md.; Natick Laboratories, Natick, Mass.; and several contractors.

The U.S. Army Behavioral Science Research Laboratory has developed computerized mathematical personnel assignment models, command and control systems, night vision devices, and improved combat proficiency predictions. Recent accomplishments in the basic research area have been development of an aptitude test useful in identifying motivational failures and in measuring mental ability, and the development of computerized manpower flow models.

Of the endeavors monitored by the Environmental, the Physical, and the Engineering Sciences Divisions, perhaps the most immediately important were remote sensing of the ground environment, the people sniffer, night vision devices, and improved aircraft and body armor, including some important work being done right now on transparent armor. Work with satellite photographs resulted in better ground mapping, and has enabled cartographers to correct erroneous maps. Also well on the way is a technique, called multi-spectral analysis, which will permit determination of militarily significant aspects of soil type and condition for trafficability purposes, and ground formations and other information from simultaneous photographs.

A great deal of work is being done with various types of lasers and many potential applications are undergoing development. One of these involves the use of a hologram for storage of three-dimensional information. A hologram is a two-dimensional photographic record containing the necessary information to provide a three-dimensional reproduction of an object. It is made by combining on a photographic plate (or other light-sensitive medium) scattered light from the object with a reference beam of light; the light from a laser is used in order that the reference beam may form a proper interference pattern with the scattered light. When the exposed film is viewed using a laser, a true three-dimensional image

is produced, which may be photographed in the ordinary manner from aspects just as though the actual object were available.

Using these techniques, a large number of holograms may be stored in a single, small, light-sensitive crystal. Storage of thousands of different scenes in one crystal is possible. Potential applications of holography under investigation include use in read-only memory for computers, eliminating the necessity for highly accurate registration of information bearing cards, and in surveillance work where multiple holograms on a single film may provide more and better information.

In another area of research, wind tunnel testing of scaled models is an established practice for simulating the real aerodynamic flow field of conventional fixed-wing aircraft. In the case of V/STOL aircraft, errors in simulation caused by the interaction of airstreams with tunnel walls had been recognized and supposedly corrected to allow accurate predictions of performance of an actual V/STOL aircraft in flight. Army-funded research on the interaction of downwash on wind tunnel walls showed gross inaccuracies in the simulation of rotary wing flight. For a given size V/STOL test vehicle, the optimum shape and size of a tunnel, the maximum and minimum wind speeds which will yield meaningful results, the permissible downwash angles, and the positioning of the test vehicle in the tunnel were determined. Conversely, for a given wind tunnel, the maximum size model that can be tested meaningfuly was determined.

The immediate effects of this research are re-evaluation of previous V/STOL model test and design data, redesign of proposed new wind tunnels, and establishment of proper model sizes for existing wind tunnel installations. This is not really a typical example, because it is rare that basic research yields such recognizable and timely benefits. It has been estimated that "incurred and anticipated expenditures on aircraft and associated wind tunnel facilities influenced by this research will easily amount to several hundred million dollars."

Research Results in Biomedical Field

The translation of research results into applications is particularly rapid in the biomedical field. Hepatitis has been a threat to military operations throughout history. Non-effectiveness of those afflicted is considerable, due to the prolonged hospitalization and convalescent period usually required. The goal of the hepatitis research program is production of an effective vaccine which would eliminate the threat of this disease. To do this, the viral agent must first be isolated and characterized. It has recently been shown that marmoset monkeys develop biochemical and pathological evidence of hepatitis when given serum from human cases. This discovery of a suitable laboratory animal represents a major breakthrough in the field of hepatitis research. The availability of laboratory animals may hasten development of an effective vaccine, and at far less cost than expensive field experiment.

Similarly, malaria has decimated more armies throughout history than any combination of man-made weapons, and it has become a major problem to the U.S. Army. Particularly virulent strains of malaria have been encountered in Vietnam and, as many readers probably are aware from reading magazine and newspaper reports, the falciparum strain also turned out to be drug resistant. A program, which has screened over 125,000 drugs, identified about 15 as showing great promise in humans, and several times this number which look good but are not ready for human testing. Cost of the program, plus some research into the mechanisms of the disease, is running approximately $10 million annually.

A spray adhesive was developed by the Medical Research and Development Command for emergency use to stop otherwise uncontrollable bleeding. The technique is still in the experimental stage, and is used only when other hemorrhage control measures fail. It is credited with saving the lives of seriously wounded men in Vietnam, particularly those with liver and kidney wounds, when usual surgical techniques are ineffective. One of the materials used is isobutyl cyanoacrylate.

A new drug, sulfamylon, extensively tested by the U.S. Surgical Research Unit at Brooke Army Medical Center, Fort Sam Houston, Tex., has resulted in dramatic improvement in treatment of seriously burned patients.

And lastly, a new approach to vascular surgery greatly reduces the number of amputees in combat wounds, as well as in cases of limb injuries from automobile accidents.

Many more examples of direct applications could be cited which incorporate or depend upon advances in science, in techniques, or in materials. A great deal of effort produces less tangible results, often with no foreseeable immediate application, but representing small, finite additions to the nation's store of knowledge.

Relevance of Research

This leads to consideration of the subject of relevance of research results to assigned missions, functions, or responsibilities, a subject which is receiving increasing attention because of budgetary constraints and the need to achieve the greatest return from the shrinking research dollar. The Army Research Council, addressing this subject and the fundamental reason for Army involvement in science and research, stated:

> **A major reason for Army involvement in science and research is to assure that all technological areas important to the Army are exploited. Some of these areas which are of particular concern to the Army, or in which it has a dominant role, are Explosives, Ground Mobility, Tropical Medicine and Chemical and Biological warfare. The Army must be the leader and actually perform the bulk of the research in these areas or the work would not be done.**
>
> **There are many other areas of research covered by other organizations within the Federal Government, in industry and in the academic world, in which the Army must also engage. A few examples are electronics, materials, medicine and meteorology. It is necessary for the Army to do research in these areas in order to fill gaps and study fundamental problems having direct bearing on its mission. Such considerations as mobility, ruggedness, and reliability have special importance to the Army and clearly justify Army participation.**

The Army Research Plan (ARP), prepared by OCRD, provides guidance to the research and exploratory development programs to ensure that they are responsive to the long-range concepts and materiel objectives of the future.

Recently, in the preparation of the ARP, the current research program was thoroughly reviewed to ensure that the scientific and technical areas of most interest to the Army are emphasized, and that favorable balance among areas is attained. Factors considered include:

- Current state of the art in the area.
- Probability of significant returns from the work.
- Relevance of the research to the Army's mission.
- Maintenance of in-house know-how, particularly in those areas where industry has little interest.

To clarify this point, two general goals can be defined for the Army research and exploratory development efforts. First, the larger portion of the effort is directed specifically toward generating technology needed for operational objectives. Second, some of the effort is expended to seek and capitalize on unexpected developments in science or technology. Both types of research can benefit from the development of valid, long-range research objectives which can provide direction to, but not unnecessarily restrict, the research effort.

A meaningful list of research objectives is critical to all stated aims of the ARP. An approved list of Operational Capability Objectives has only recently become available. Prior to this, as an interim measure, a list of objectives was derived from the OCRD research planning guidance statements and the Joint Research and Development Objectives Document.

In order to obtain an overview of the manner in which the research program supports these objectives, exploratory development projects were appraised against 179 detailed objectives. Judgments were made on the degree of relevance of the project to the objective and as to the adequacy of the current level of support. The research projects were linked indirectly to the objectives by appraising them against the exploratory development projects in a similar manner. The result is a qualitative profile of the research program which, hopefully, can become a useful management tool. A similar exercise will be conducted using the approved Operational Capability Objectives for the next edition of the ARP, expected in the fall of 1969.

As has been pointed out in the recent Army Research Council report: Past Army research has contributed materially in the context of "payoffs" in the modern Army. Innovations are clearly evident in the manner in which the Army moves, uses firepower, communicates and sustains itself. These achievements are not insular to the Army, but have had incidental impact, so far as the Army is concerned, on the economies of the nation and the world. A few examples of these are:

- The computer industry was further stimulated by Army research at Aberdeen Proving Ground to provide a computing capability for firing tables.
- Recent research in low-speed aerodynamics has led to major improvements in helicopters and hovering aircraft.
- Army research and research support of microminiaturized electronic circuits provided a substantial basis for that industry. In a related field, the first satellite communication systems were built through Army research.
- The Army's need for prepackaged food for field rations led to several food preparation industries, such as irradiated and dehydrated foods.
- Army medical research established large areas of activity, such as public sanitation, tropical disease control, blood-handling procedures and burn treatment.

The Army will continue to possess an imaginative and productive research organization capable of exerting an aggressive role of leadership in all scientific fields responsive to its needs.

Office of Naval Research

Research Today for Tomorrow's Navy

Rear Admiral Thomas B. Owen, USN

Man today can routinely dive more than a mile down to the ocean bottom in a research submersible to peer and grope at its alien environment; gather scientific data telemetered daily from an unmanned buoy moored hundreds of miles out at sea instead of waiting for a research ship to return to port months later; live and work on the ocean floor for weeks in a scientific laboratory; and receive a blood transfusion of whole blood obtained many months before and preserved by freezing. This and much more can be accomplished now as a result of Naval research carried out yesterday.

Within the Navy, all research and development is under the direction of the Assistant Secretary of the Navy (Research and Development). "Research and development," although commonly used as a single expression, actually connotes a wide range of endeavor. Indeed, the appropriation which provides the Navy with funds for its research and development program is entitled "Research, Development, Test and Evaluation, Navy."

Procurements which carry the label, research and development, range in size from small basic research contracts, wherein the Navy supports fundamental studies, to large contracts for the fabrication of the first prototype of an operational system. As an equipment procurement moves down the path to operational systems development, the requirements become more definitive, the planning more extensive, and the work more costly to perform.

The responsibility for the part of the Navy research and development program, designated as Defense Sciences (Research), rests with the Chief of Naval Research who heads the Office of Naval Research (ONR) and reports directly to the Assistant Secretary of the Navy (Research and Development). The establishment of the Office of Naval Research dates back to 1946, when it became the first

U. S. agency with the major mission of supporting research at American universities and laboratories by contract.

Its establishment represented a unique and even revolutionary move at the time. Prior to this, the Federal Government had little experience in negotiating and administering long-range basic research contracts with universities or private research organizations. The standard government contract up to then was primarily designed to cover the purchase of tangible goods or specific services, generally from industry.

As the first permanent Federal agency to support basic research, the Office of Naval Research, in many respects, has served as the patternmaker in the government support of research for Army, the Air Force, the National Science Foundation, the National Institutes of Health, and the National Aeronautics and Space Administration.

The basic mission of the Office of Naval Research, with headquarters located in the Main Navy Building, Washington, D. C. 20360, is to plan, promote, initiate, conduct and coordinate Naval research. While concerned primarily with basic research, ONR also sponsors applied or directed research, as well as some exploratory developments leading to experimental prototypes. Basic research is considered the predominant area of research, and is aimed at gaining broad fundamental knowledge of a scientific field with a pure science approach.

Rear Admiral Thomas B. Owen, USN, has been Chief of Naval Research and head of the Office of Naval Research since July 1967. Before this assignment, he served as Director of the Naval Research Laboratory, and has held numerous positions in the Navy in the research and development field. Admiral Owen holds a B. S. degree in chemical engineering from the University of Washington, and a Ph.D. in chemistry from Cornell University.

In practice there is a carefully planned program to build up knowledge in every scientific discipline that can potentially be related to Naval operations. Frequently, specific Navy benefits to be gained from the research are unpredictable at the start of the study. In many cases, Naval research attempts to have a solution to a problem ready before the problem arises.

ONR's program of supporting research through contract awards is based largely on unsolicited proposals. These are both formal and informal and come from all types of research groups, including universities, private institutes, and industrial laboratories.

In cases where the research objective requires experimental hardware, ONR solicits proposals in order to select responsible contractors who are technically qualified to perform the necessary specialized work. Since the preparation of technical proposals can be costly, an attempt is made to limit requests for proposals to those sources which are qualified to perform the planned tasks. In order to stimulate and increase competition, however, a concerted effort is made to expand the number of qualified sources. One aspect of doing this is to encourage small business concerns to submit their qualifications. Within ONR, proposed procurements for industry are reviewed by small business specialists to determine that proper consideration is given to participation by small business.

ONR's objective is to prepare a contract which clearly and completely outlines the task to be done and, at the same time, permits flexibility and encourages creativity. Also, ONR has attempted to make contract reporting compatible with its needs without making excessive demands on the contactor.

The entire Navy Patent Program is operated by ONR, providing professional services and advice to Navy personnel and contractors with respect to patents, inventions, trademarks, copyrights and royalty payments.

Branch Offices

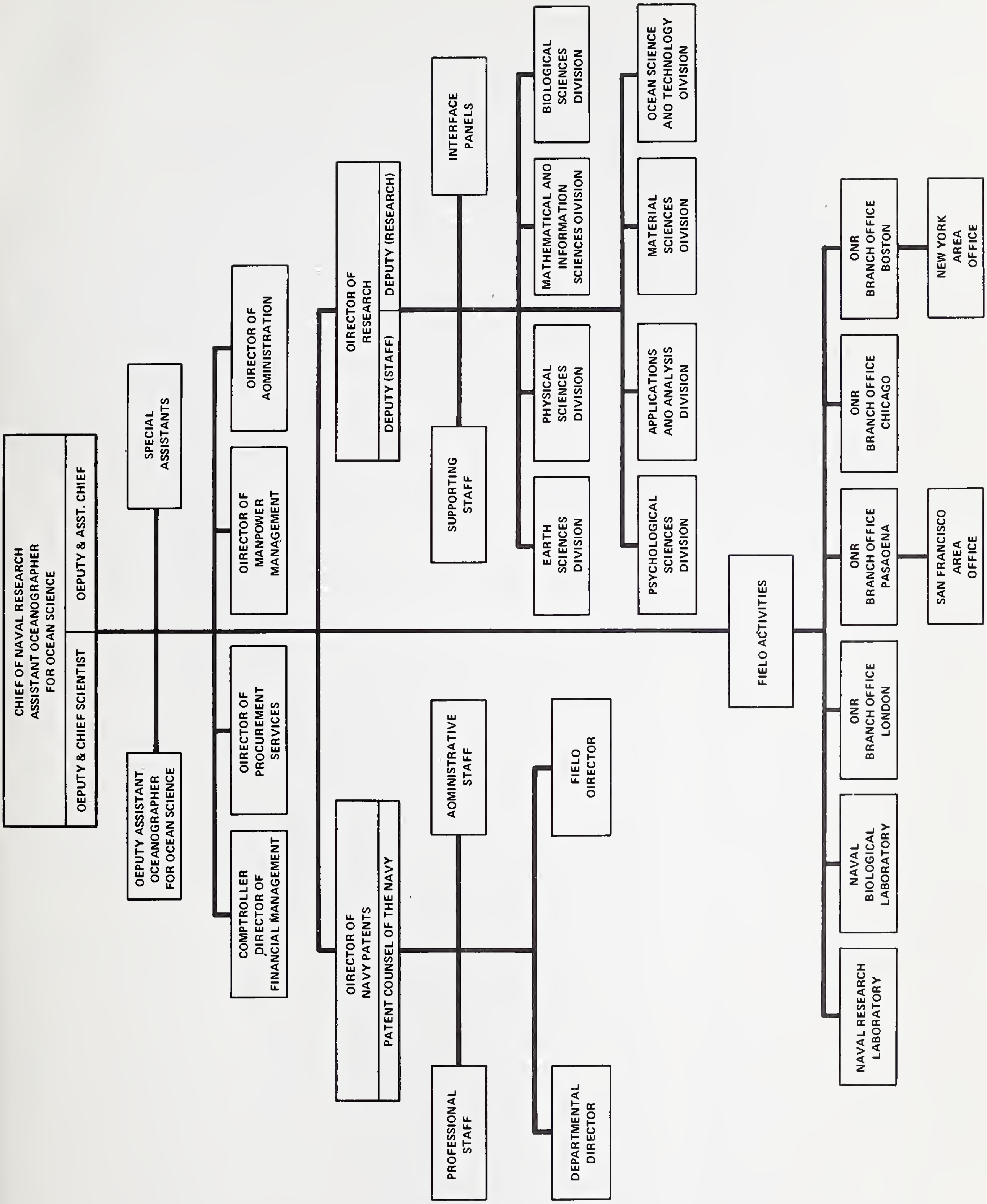
To maintain close relations with the contractor or potential contractor, ONR operates branch offices in Boston, Chicago and Pasadena. The Boston branch office maintains an area office in New York, and the Pasadena office operates an area office in San Francisco.

Branch offices facilitate direct liaison between ONR and scientific institutions, research investigators and contractors. They report on research findings, trends, potentialities and achievements. Furthermore, they monitor ONR tasks and research projects to identify and report on scientific and technological advances that have potential importance to the Navy. In addition, the contract administration department of each office performs comprehensive contract and property administration services on research contracts and grants placed with various institutions.

These services, involving contracts with educational institutions, are provided not only for the Navy but also for the Army, the Air Force and the National Aeronautics and Space Administration.

Within the branch office areas, there are 24 resident representatives, located at major universities, to provide contract administration services on a more localized basis. The branch offices also have an Office of Patent Counsel to assist contractors in patent and copyright matters.

In addition to its continental branch offices, ONR operates a branch office in London, England. This office represents the Assistant Secretary of the Navy (Research and Development), the Chief of Naval Operations, the Chief of Naval Material, as well as the Chief of Naval Research, in all matters of general scientific and technical interest to the Navy in the United Kingdom and Europe. The London office surveys scientific trends, potentialities, and achievements in research and development by maintaining liaison with all agencies in those areas conducting programs of interest to the Navy. The work is performed by a staff of U.S. scientists and Naval officers who regularly visit academic, industrial


CHIEF OF NAVAL RESEARCH
ASSISTANT OCEANOGRAPHER FOR OCEAN SCIENCE
DEPUTY & CHIEF SCIENTIST
DEPUTY & ASST. CHIEF
SPECIAL ASSISTANTS
DEPUTY ASSISTANT OCEANOGRAPHER FOR OCEAN SCIENCE
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ONR BRANCH OFFICE LONDON
NAVAL BIOLOGICAL LABORATORY
NAVAL RESEARCH LABORATORY

and governmental research and development organizations in the United Kingdom, Western and Eastern Europe, and the Middle East.

ONR Laboratories

The Office of Naval Research operates one in-house laboratory, the Naval Research Laboratory (NRL) located near Washington, D. C., and two other laboratories under contract.

NRL was established in 1923 to ensure that advancements in science and engineering could be applied readily to Navy needs. When ONR was established by Congress in 1946, the laboratory came under its control and formed an important element of the organization.

The mission of NRL is to conduct scientific research and development in the physical sciences and related fields directed toward new and improved materials, equipment, techniques and systems for the Navy. The laboratory occupies 126 acres of land and employs 3,600 civilians, of whom some 1,900 are members of the Research Department. NRL field activities, scattered from New York to Florida, provide unique environments and facilities not available at the Washington, D. C., site.

One of the two laboratories operated by ONR through contract is the Naval Biological Laboratory in Oakland, Calif. This laboratory is operated under the command of a Naval officer who reports to the Chief of Naval Research. Its research is conducted through contract with the University of California School of Health. Recognized by the scientific community for its excellence in aerobiology research, the laboratory also emphasizes medical and environmental microbiology.

The other laboratory is the Naval Arctic Research Laboratory (NARL), operated by the University of Alaska through a contract with the Office of Naval Research. Well equipped laboratories at NARL support all forms of basic and applied research related to the Arctic, particularly in the fields of oceanography, marine biology, geophysics, and underwater acoustics. NARL also maintains an extensive network of semi-permanent, permanent and temporary research camps on land and drifting stations within the ice pack of the Arctic basin. The area of operation on land includes all of Alaska northward and westward from the Brooks Range to the coast. At sea, drifting stations are established and maintained largely within the Chukchi and Beaufort Seas although one ice station has drifted as far as the Greenland Sea.

Challenges and Achievements

During its 21-year span of research ONR has met formidable challenges offered by science, and achieved new scientific knowledge to maintain the Navy's control of the ocean on behalf of national security.

A good example of long-range basic research and how it can eventually result in broad applications is the story of the maser and the laser. ONR has played a key role in outlining, planning and supporting research in this field, just as it has in solid state physics and other areas of physical sciences. Work in the general field of microwaves spectroscopy supported by ONR, the Army and the Air Force led to the discovery of the maser.

The Navy made good use of the maser in low-noise receivers for radio telescopes and developed an ultra-precise atomic clock for a navigation system. Later ONR-sponsored research in this field contributed to the discovery of the laser. Given responsibility in that field by DOD, ONR has made major contributions to laser research and technology. New materials and improved pump sources for the laser have been studied and developed to achieve maximum brightness and high power. One ONR-supported research project is studying the idea of employing a laser beam in conjunction with conventional radar to obtain a sharper resolution.

One of the early fields of science that felt the impact of ONR effort was nuclear physics. The programs enabled the United States to move vigorously ahead in this field, and ensured that no time was lost in the interim before the Atomic Energy Commission (AEC) was established. Most of the 15 nuclear accelerators, which were built at universities in the decades following World War II, were started under ONR sponsorship. Funds were provided for the construction and operation of a linear electron accelerator at Stanford University, which led to the building of the new two-mile linear accelerator for AEC at Stanford. During the development of the linear electron accelerator, Stanford University scientists were faced with the problem of generating very high power required to accelerate the electrons to the proper speed. This problem was solved with the development of the klystron tube. The klystron, in turn, aided materially in the early development of high-powered radar.

Now, Stanford scientists are attempting to improve the accelerator program by making use of the phenomenon of superconductivity—the fact that electronic efficiency improves under supercold conditions. ONR is currently supporting the development of the cryogenic linear accelerator at Stanford not just for interest in nuclear physics, but because there is a belief that this basic research program should lead to advances in demonstrated application of cryogenic technology to Navy equipment problems.

ONR envisions that the use of cryogenic technology may result in such applications as gyroscopes virtually free from error, powerful magnets energized by a few storage batteries, and shipboard electronic equipment much more compact and reliable. Just as an understanding of the principles involved in this field was obtained from basic research, so it is now that basic engineering problems must be solved before it can become a full-blown technology. Toward this end Stanford scientists will employ the first large-size refrigeration system ever used to maintain an operating electronics system at a temperature 450 degrees below zero F.

Spin-off Aids Civilian Needs

Most types of Naval research have broad applications. In the case of biological research, work aimed clearly at Naval personnel has a much broader application. The Navy sponsored research aimed at developing techniques both for storing whole blood for long periods of time by freezing, and then being able to thaw it quickly and safely for immediate transfusions. Frozen blood has been used sucessfully by all the Military Services in Vietnam, and can be used for civilian purposes as well.

In fact, the use of frozen blood proved invaluable to the civilian community in the Boston area in

December 1968 during a flu epidemic when conventional supplies of blood were critically low. One civilian hospital in that area is now using frozen blood in surgery cases requiring large amounts of blood as in open heart surgery.

Another area of interest is the preservation of human tissues of different types. A number of casualties in Vietnam, suffering serious head injuries, were saved because of the availability of preserved dura, the brain lining lying just below the skull. Once again, an area of Navy interest can be of great value to the civilian population as well.

Included in biological research is the study of dental caries among Navy recruits. Investigations have proven that recruits reporting from certain parts of Ohio, South Carolina and Florida have no cavities at all. In addition to fluoridated water, which is known to help prevent caries, scientists have theorized there are certain chemicals in foods grown in those areas that inhibit the growth of cavities. Today, ONR continues to sponsor research to identify these chemicals. The solution will affect both the Navy and society as a whole.

Effective Relationship of Man and the Machine

The Navy has long recognized the value of research in the psychological sciences, particularly in drawing men and machine together in a more effective relationship. ONR is presently engaged in a program of better integrating the aircraft and its crew. The objective is to improve both the many displays and the operations that must be performed, in some cases on an emergency basis. ONR pioneered efforts to provide adequate protection to minimize hearing damage to men working close to jet engines.

In another area of psychological science, a current research program is underway in the field of human engineering. It is aimed at the development of a servo-powered, "exoskeleton" structure to be worn by man to augment his strength and lifting powers up to 1,500 pounds. It would be used by the Navy and others in areas where heavy lifting equipment cannot be installed readily.

The Navy envisions the computer as the key to significant improvements in human performance. In this area work is being directed toward development of more effective communication between man and computer. The tireless computer can improve the quality and can speed the teaching of recruits. This improved teaching method is necessary to train effectively the large number of young men required to operate and maintain highly sophisticated Naval systems. The Naval Academy, in a pilot program, has already installed an educational computer that is programmed for a variety of language, social science, engineering, and mathematical courses for midshipmen.

Oceanographic Research

Among the first programs started at ONR was oceanographic research. New ocean-probing tools have been developed, including ships especially designed for oceanographic research. Common examples of tools being used today as a result of such research are gravity meters, magnetometers, underwater TV cameras with strobe lights, and many others. Much of the equipment presently in use aboard these ships resulted from ONR-sponsored research.

More recently, ONR has developed the first long-range, unmanned, telemetering oceanographic buoy, capable of recording a variety of data from down to a depth of 20,000 feet and telemetering it up to 2,500 miles back to shore-based stations.

During the past decade, oceanographers had searched for such an instrument or vehicle that would handle deep sea data over a long period of time. The ONR-sponsored project for the development of such a buoy was the answer. The buoy is appropriately labeled the "Monster Buoy" because of its huge size, being 40 feet in diameter. Information recorded by the buoy's sensors may be telemetered daily by up to 100 channels to shore-based data stations, or can be stored in another memory system at sea unattended, for as long as one year. The development of the Monster Buoy has, thus, provided oceanographers a convenient system for obtaining a variety of information much more rapidly and efficiently than was before possible.

The development of a deep-diving research submersible, through ONR-sponsored research, has opened up a new world of scientific promise by its capability to dive more than a mile down to the ocean's bottom to obtain scientific data.

ONR initiated the operation of deep-diving vehicles in this country with the purchase of the bathyscaphe Trieste in 1958. This vehicle made the first major conquest of the ocean depths when the Navy took it down into the deepest ocean trench known to exist, the Mariannas Trench, descending to an official depth of 35,800 feet, a record that still stands. Recognizing that deep-sea research required a submersible that could maneuver, ONR turned to American industry which provided Alvin, the first deep-diving research submersible to go into operation.

Two new and improved versions of Alvin, the Sea Cliff and Turtle, are nearing completion. The Turtle, owned by the Naval Ships Systems Command, will work with ONR's Sea Cliff to be operated by the Woods Hole Oceanographic Institution, in a joint program beginning this summer.

These twin submersibles, which have a depth capability of 6,500 feet compared to the Alvin's 6,000 feet, are equipped with a vast array of scientific gear, plus television and other cameras equipped with strobe lights to obtain vivid photographs underneath the ocean. The submersibles are also equipped with a pair of remotely controlled mechanical arms that can obtain data from the water and ocean floor for further scientific study.

The broad application of Naval research is exemplified by the Navy's man-in-the-sea program. The pioneering Sealab I and Sealab II experiments, conducted by ONR in 1964 and 1965, established that man can live and work safely on the ocean bottom for long periods while conducting salvage and rescue operations, scientific studies, undersea mining, or underwater oil drilling.

TEKTITE I is a new project in this area, under the technical direction of ONR and supported by NASA and the Department of Interior, with the undersea habitat designed, built and furnished by the General Electric Co. The operation involved a team of aquanaut-scientists who lived in the habitat on the ocean floor at a depth of 50 feet for 60 consecutive days and conducted marine science studies in the area outside their habitat. At the same time their behavior was observed by psychologists and biochemical special-

ists using computer techniques for collecting and analyzing the data. The objective of the investigation was to gain more knowledge of marine science and the behavior of a small group of men confined in close quarters in a somewhat hazardous world. This data can be applied to both future undersea missions and to extended manned space missions.

For the past two decades research sponsored by ONR has not only greatly improved Naval capabilities, but has also had a direct effect on achieving major scientific advancements for our society. Such basic and applied research is vital to the continued effectiveness of the Navy, as well as the progress of the nation. Research conducted today will lead to the discovery tomorrow of new concepts and principles from which new technologies will evolve and major developments for our society will spring.

The operational capabilities of the Fleet today is the result of scientific research performed years ago. This "time lag" tends to mask the very real and direct benefits the Navy gains from basic research. The final impact of Naval research can never be measured fully or identified because it may be decades before the potential of a new principle, such as the laser, is fully exploited. Naval research, therefore, plays a key role not just in the future of the Navy but in the future of man.

Office of Aerospace Research

Management of Air Force Research

Brigadier General Leo A. Kiley, USAF

Albert Einstein once said that the most incomprehensible thing about the world is that it is comprehensible.

All research scientists work on this principle as they seek knowledge and understanding not only of *how* something behaves but *why* it behaves a certain way.

Research is a search for knowledge and understanding of the physical world, while technology is an attempt to get some measure of control over physical processes.

It required only six years from the control of nuclear fission in a laboratory experiment to the explosion of the first atomic bomb. In the process, the art of warfare was revolutionized.

While science and technology played an important part in World War I, it was a secondary role as compared to World War II. During World War II the allies, for the first time in history, enlisted the aid of organized science for the decisive contribution of effective weapons. Never before had such large numbers of scientific workers been united for planned evaluation and utilization of scientific ideas for military purposes. This effort has continued to the present, and today, more than ever before, research is an important mission of all of the Military Services of the United States, as well as other countries.

The U.S. Air Force research program is the responsibility of the Office of Aerospace Research (OAR), located at 1400 Wilson Blvd., Arlington, Va. 22209. It is a challenging management responsibility and plays a vital role in the future of the Air Force and the security of the United States.

As a separate operating agency, OAR reports directly to the Air Force Chief of Staff on the same level as the major operational commands. Organizationally OAR is composed of five scientific organizations, two scientific support units, and three field detachments. With the exception of the Air Force Office of Scientific Research (AFOSR), all of our scientific organizations are in-house laboratories. AFOSR, the broadest in scope of our subordinate units, is our major interface with the overall world-wide scientific community and conducts its research through grants and contracts.

The two scientific support units represent our foreign research programs and have offices in Europe and South America. The field detachments, operating as part of OAR headquarters, are responsible for satellite, rocket, and balloon programs which provide our scientists with the means for getting their experiments into the upper atmosphere.

Compared to other Air Force commands, OAR is a small organization. Its 2,080 people represent about 0.2 percent of the Air Force personnel. Three out of four are civilians. About half of the people are assigned professional scientific and engineering duties. Sixteen percent of the military and 29 percent of the civilians have doctorate degrees, and 67 percent of all the professionals possess graduate degrees.

OAR physical assets are valued at approximately $95 million with $55 million in equipment and $40 million in buildings and real estate.

Four Phases of Research and Development

The Air Force research and development structure is divided into research, exploratory, advanced, and engineering development.

OAR is responsible for all of the research endeavors of the U.S. Air Force and a small segment of its exploratory and advanced research. Research funding within the Air Force amounts to 2.6 percent, or about $90 million of the $3.4 billion overall research, development, test and evaluation (RDT&E) program. The Air Force Systems Command (AFSC) manages most of the remainder.

In addition to the $90 million for research, additional funding for work in the exploratory and advanced portion of the research and development structure provided by AFSC and other agencies brings OAR's total funding to approximately $130 million. In an average year OAR will obligate $50 million for contracts and grants with 73 percent going to educational institutions, 23 percent to industry, and 4 percent to nonprofit organizations.

Air Force research efforts are divided into areas of physical, engineering, environmental, and life sciences. These areas, in turn, are divided into 13 sub-elements.

The physical sciences, which include general physics, nuclear physics,

chemistry, and mathematics, account for 35 percent of our efforts. The engineering sciences, including energy conversions, mechanics, materials, and electronics, total 33 percent; while environmental sciences, divided into atmospheric and terrestrial sciences, total 26 percent. The life sciences amount to 6 percent and include biological, medical, behavioral, and social sciences. Each of these areas is relevant to Air Force research requirements. Our research includes practically all areas of science with the exception of oceanography, which is exclusively within the Navy research program.

Planning Military Research

In the military, as well as in industry, a good research program starts with careful planning. The Joint Chiefs of Staff publish a Joint Research and Development Objectives Document which is distributed to each of the Military Departments and is necessarily very broad in scope. In turn, the Air Force publishes the USAF Planning Concepts document which looks as far as 15 years into the future. This document includes such items as technical horizons, analysis of the international scene, doctrines of concept, and desired capabilities. The staff of Air Force headquarters is assisted in the preparation of the plan by the field organizations: Strategic Air Command, Tactical Air Command, other operational commands, AFSC and OAR.

Using the Air Force plan as a guide, OAR publishes a Five-Year Plan which is revised annually, and includes in detail the organization, missions, resources, and scientific and technical efforts. It enables the OAR headquarters staff and subordinate commanders to carefully plan ahead and is an important part of research management. The Five-Year Plan is an internal publication with distribution limited to government agencies.

From the Five-Year Plan, the portion concerned with scientific and technical efforts is extracted and published as the OAR Research Objectives. This publication is widely distributed to educational institutions, nonprofit organizations, and industry. It provides information to help recipients present unsolicited proposals to the proper organization within OAR.

Individual research contracts and grants are generally small compared to the large sums expended on development contracts. OAR seeks to buy "brainpower" to supplement in-house capability. Contractors do not generally need large facilities to compete for this type of work. Research proposals are selected on the basis of relevance, originality, and the caliber of the principal research investigator.

Managing Research

Successful management of research calls for considerable background in research itself, in order to intelligently manage what is, in effect, a creative effort on the part of the investigator. We feel that OAR enjoys a good reputation in the scientific world, and this reputation itself assists management at all levels.

While we operate on the premise that research is primarily a search for knowledge and understanding, and to increase our stockpile of knowledge, in a military mission-oriented organization there is a more practical objective in terms of known or anticipated military problems. This is true at the management level, but is not necessarily always true at the investigator's level. We especially seek scientific areas that have strong military relevance and perform research to provide the technological base for further developments and future production of military equipment. Thus, in a very real sense, research management decisions of today have a critical impact in determining military operational capability some years in the future.

The fundamental characteristics of research differ markedly from those of development or production. Technical feasibility is unknown—in fact, it is the objective. Research is not a repetitive process, but a unique effort. The degree of success, time phasing, and costs can only be estimated since they are so dependent on scientific progress. Breakthroughs in research cannot be forecast with any degree of accuracy whatsoever. Thus, major management problems relate to such questions as which technical areas and scientific fields warrant further investigations; what studies, analyses, and investigations should be curtailed or deemphasized.

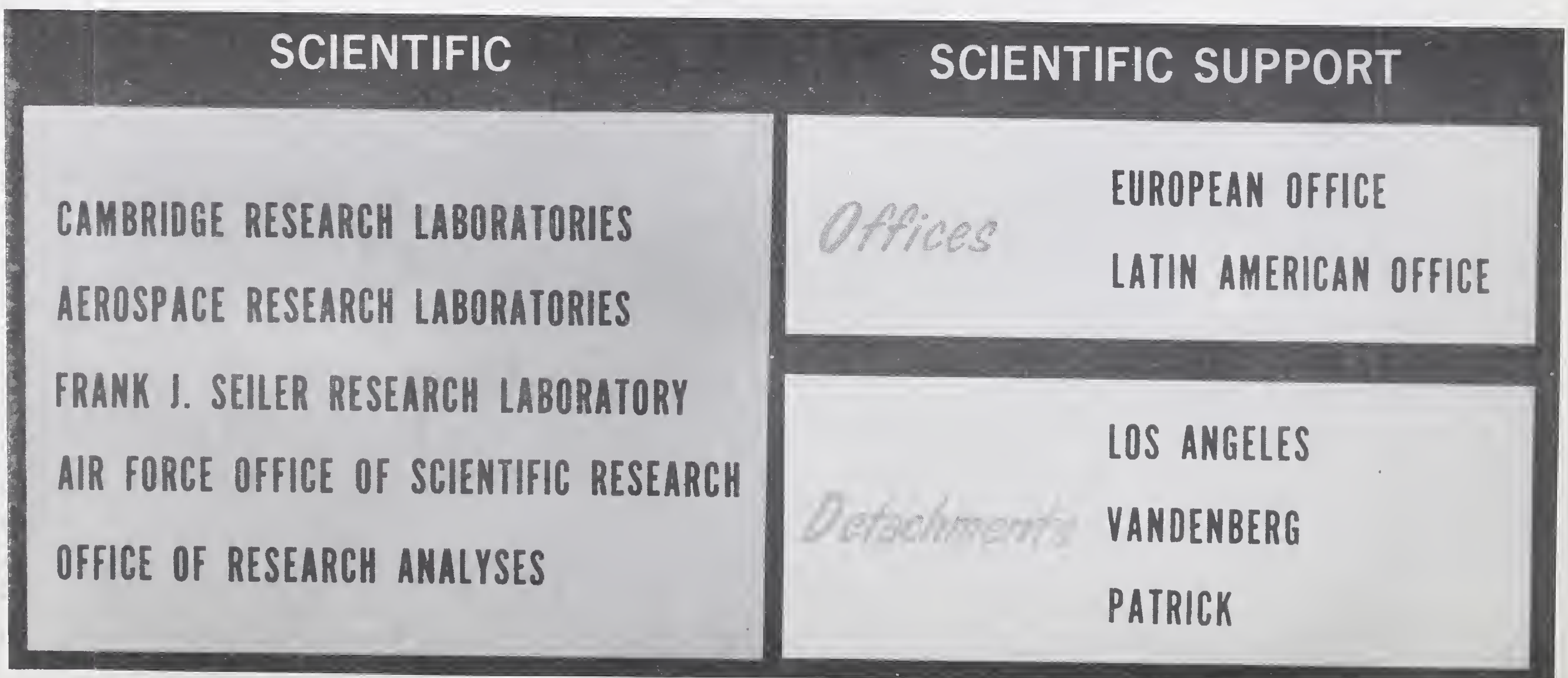
Since these kinds of decisions can be made most effectively at or near the working level, *i.e.*, the laboratory or project scientist, the fundamental principle of research management in the Air Force is the maximum delegation of authority. The primary management control exercised at Air Force headquarters and OAR headquarters is in terms of level of effort, such as allocations of resources to general technical areas or scientific fields, with broad authority delegated to subordinate commanders. They, in turn, delegate a considerable amount of this authority to their project scientists at the lowest level. Most operating decisions are made at project scientists' levels with broad general limits and within scope of available resources.

Resources are limited, and frequently management must decide among several desirable efforts—to say it another way, priorities, in the classical sense. However, one cannot make a list of all efforts, rank

Brigadier General Leo A. Kiley, USAF, is Commander of the Office of Aerospace Research. Prior to assuming this command, he was Deputy Director of Development, Office of the Deputy Chief of Staff for Research and Development, Headquarters, U. S. Air Force. He has also served as Commander, Air Force Cambridge Research Laboratories, and Commander, Air Force Missile Development Center. General Kiley holds a B.S. degree in chemical engineering from Massachusetts Institute of Technology and a Ph. D. in nuclear chemistry from Ohio State University.

OFFICE OF AEROSPACE RESEARCH

1400 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22209



them in order of priority, and then allocate available resources starting at the top of the list. In broad areas, of course, some rankings can be made but individual resources often are not interchangeable, and it is difficult to forecast the probability of technical progress, the ultimate impact of a scientific investigation, and the relative value of a research study versus an end-item development. Consequently, most resource allocation decisions must be made primarily on the basis of judgment, experience and intuition.

In the defense research sciences, which is the hard-core research program, projects are planned, documented, and resources are programmed in advance. In one sense, priorities are, of course, established in the allocations of funds each year to the various projects. A guiding principle, in this case, is to insure reasonable stability in these longer-term projects. Thus, to the extent possible, project needs are anticipated and provided for in advance.

Nevertheless, unforeseen contingencies do arise, particularly in a research-oriented agency such as OAR. Decisions have to be made or priorities must be established when a promising idea comes along. In each case, the probable value resulting from the proposed effort must be weighed against the potential loss from reduction in resources for other efforts. These problems may arise at any management level, but the level at which the decision is ultimately made depends on the scope and importance of the particular problem. Thus, although many decisions are made by project scientists by shifting resources available to them, in other cases the matter must be resolved by the laboratory commander, and sometimes must be referred to OAR headquarters or even Air Force headquarters for the final decision.

In addition to the hard-core research program, OAR does work for, and accepts contractual funds from, various government agencies within and without the Air Force. Normally, these efforts are relatively short term and result from a specific request from the sponsoring agency. Acceptance is subject to the approval of the laboratory commander, and the work must be in an area where the laboratory has a related program and scientific competence.

Also as a matter of policy, OAR encourages the participation of all of its scientists to support development and system activities in their particular fields of interest. Frequently, this support is limited to advice and consultation to the developing agency. Often, however, the work involves more detailed investigations or conduct of specific experiments and tests, and in some cases includes development and evaluation of end-item equipment for Air Force use.

Scientists in our in-house laboratories are encouraged to devote a substantial part of their time to developing an awareness of Air Force problems within their technical areas, and consulting with other Air Force elements and users of OAR research. This requirement is written into the job descriptions of all military and civilian laboratory professional personnel.

OAR is very conscious of its obligation to the operating Air Force. We believe that participation is the most effective means of coupling research results into development and production programs. In addition, the knowledge and experience gained by the scientists are invaluable in increasing their understanding of operational problems. This policy is essential to maintenance of a viable and responsive research program, and I consider it an excellent management tool.

As commander of OAR and a manager of Air Force research, it is my responsibility to have a strong interface not only with the scientific community, but also with the potential users of research and those concerned with long-range planning.

Interaction with the Office of Naval Research and the Army Research Office is frequent—if not daily. This interaction between Services takes place both at bench scientist and management levels, and also applies to other government organizations, such as National Aeronautics and Space Administration, Defense Atomic Support Agency, Federal Aviation Agency, and the National Science Foundation. Sometimes OAR participates directly in activities with the President's Scientific Advisory Council and the Federal Council for Science and Technology.

OAR representatives regularly attend Air Force Systems Command Planning Board meetings, the Director of Laboratories directors meetings, coupling meetings, and techical management conferences.

Monthly I personally meet with the AFSC Science and Technology Management Council, which is composed of general officers of the System Command, the staff of Air Force headquarters, and a representative of the Assistant Secretary of the Air Force (Research and Development).

The working relationship with the Directorate of Doctrine, Concepts and Objectives in the Office of the Deputy of Staff, Plans and Operations, in Air Force headquarters, involves effective person-to-person communication with a minimum of red tape. This communication enables OAR to contribute its scientific brainpower to long-range planning concepts and to projections of the technological world ahead of us. In return, we perceive in sharper focus where to pursue research.

Serendipity vs Managed Results

In some ways management of research may be likened to managing the unknown. Serendipity and research go hand in hand. An interesting example is the research of Nobel Laureate Charles H. Townes who, two decades ago, was studying the interaction between microwaves and gas molecules. To many investigators few areas of physics appeared to be less promising. However, Air Force management supported his work to the extent of $100,000. As is well known, the result was ultimately the maser and, later, the laser. Everyone, of course, is familiar with the laser, but few realize that Dr. Townes' maser research was essential to the development of the atomic clock, as we know it.

Another example of where we in research management could not forecast a payoff is a product of our continuing radio astronomy program. One Air Force contractor was studying the size and location of a very small galactic radio source. One way to get size information was to view the source from widely separated stations. Consequently, sensitive radio astronomy antennas were set up several thousand miles apart to receive

signals simultaneously from the radio source. These two stations made up an extremely long baseline interferometer. By knowing the precise size and location of the galactic radio source and the exact location of one ground station, the other ground station can be located to a precision far greater than any other geodetic technique—a capability which is very relevant to Air Force needs.

Knowing the exact distance between a launch pad at Vandenberg AFB and the impact area in Pacific is very important in the AFSC missile test program. Since interferometry is a technique that requires extremely accurate time synchronization between the receiving stations, the long baseline interferometer would be impossible without the atomic clock, which is so accurate that if one had been set properly more than 2,000 years ago its error would be less than one second today. This is an example of where research in quantum electronics by Dr. Townes and research in radio astronomy by other scientists was utilized to make a significant achievement with special relevancy to Air Force interests.

As it often is in research, the outcome of the two individual projects was not apparent at the beginning. Neither was the research of an English mathematician named George Boole who, more than a hundred years ago, invented a new algebriac system. As basic research it was a brilliant contribution to pure mathematics. It was logical, self-contained, and a new philosophic approach to the explanation of the universe in mathematical terms, but it seemed useless at the time. There were no problems available for it to solve. For nearly a century it was considered just another curiosity of interest only to mathematicians. It remained for another scientist, Claude Shannon, to write a technical paper in 1937 pointing out that Boolean Algebra could be applied to solve a whole new class of complex problems in the design of electronic circuits. The paper was read by Bell telephone engineers, and they almost immediately saw the application of Shannon's techniques to telephone circuitry. The techniques were successfully used to solve some of their most intricate problems in circuit design. No longer was Boole's algebra a solution looking for a problem. Today it would be extremely difficult, and perhaps even impossible to design a complex, high-speed computer circuit without Boolean Algebra.

Applying Research and Technology

Research breeds technology and technology breeds research. A novel, high-speed photographic technique employing a laser has enabled Air Force-supported scientists to gain new insight into the gasdynamics of explosions and, recently, revealed for the first time details of some of the phenomena which occur in rocket thrust chambers. This technique can yield nanosecond exposures (one billionth of a second) at megacycle rates —on the order of millions of frames per second. It permits scientists to not only see how something behaves, but offers new means to understand why it behaves in a particular manner. These studies centered around the fundamental properties of shock, blast, and detonation waves, in order to learn more about these processes. It is hoped to learn how to achieve better control over the explosion phenomena in weapons, as well as providing technology for far more powerful propulsion systems. Some typical questions being asked are: Can we drop a bomb and divert more energy laterally and less energy vertically? Can we provide a substantially higher thrust and greater stability in rockets?

As one leaves the fundamental research areas toward more applied aspects, setting of priorities can be done with greater confidence. In a few cases based on exigencies of the current Vietnam situation, research scientists with worthwhile practical ideas have chosen to follow them closer to hardware than they ordinarily would. One good example of this can be found in the low light level television area, where early concepts of the isocon camera tube approach had not reached fruition. Because of high priorities accorded the work by the research scientist concerned, by the laboratory, and with the encouragement of OAR headquarters, it was possible to pursue the concept vigorously and to compress significantly the time for development of improved tubes and cameras. This has allowed earlier evaluation of competing concepts and greatly advanced the state of the art in low light level television.

Another interesting example of research management to optimize application to Air Force interests is the work of Dr. James D. Winefordner, of the University of Florida, who has been working since 1965 with OAR support on flame spectrometry and gas chromatography. With this support the atomic fluorescence method of analysis of materials was discovered and brought to the present state of the art. This method appeared to have potential application in the Air Force Spectrometric Oil Analysis Program which is directed toward early identification of incipient failure or undue wear rates of oil lubricated mechanical parts.

The OAR project scientist suggested to the researcher that he devote a portion of his time to investigating this possible application of his work. Funds were added for this aspect of the project. With continued development, much progress has been made. The new method of analysis is now being evaluated in competition with the older methods of analysis of wear metals in aircraft lubricating oils. If expectations are borne out, atomic flame spectrometry could provide less costly, faster, and more accurate oil analysis. Not only would it save millions of dollars in aircraft maintenance, but it would also aid in preventing air crashes due to engine failure and the resulting loss of lives.

One critical area confronting the Air Force is the vulnerability of electronic systems to certain kinds of radiation. This problem exists today, and in the future there will be increasing demands for electronic components, devices, and systems that can operate effectively in the natural radiation environment of outer space, and in the severe environment produced by nuclear explosion.

About two years ago, OAR began investigating what could be done to solve the problem of vulnerability to radiation. Although some fundamental information was available from previous basic studies, it was apparent that there were large gaps in our understanding of the mechanisms of changes in solid state devices, the magnitude and nature of radiation damage, and how deleterious effects can be avoided in these hostile environments. Based on scientific competence in materials research in solid state physics, one of our laboratory directors decided

to organize a coordinated research program in radiation resistance.

A number of research efforts were phased out, or reduced in scope to obtain the necessary resources to initiate the program. The process continued and, as the program progressed, OAR received additional finanial support by AFSC. Because of progress in the investigation of radiation effects and the applications of these results in the development of electronic devices, solutions to some of the problems have been completed well ahead of schedules imposed by the using agency. We are optimistic about additional progress and solutions to other existing problems.

In these and other cases, the priorities were self-generated because of both the research area and Air Force potential requirements. The self-generated priorities are part of the Air Force research picture and, if the topics are of sufficient importance, often the scientists themselves will move toward exploratory development even at the expense of some of their other research. These informal arrangements help to optimize the organization's output even more than any formal priority system and act to preserve the flexibility so vital to research.

Sometimes there is a management decision to shift research emphasis in view of a request for support from the Air Force development laboratories. As an example, an intensive new research attack on problems of oxidation and corrosion has been initiated. This new program, which is being carried out in our Metallurgy and Ceramics Research Laboratory, is needed to guide development of alloys and protective coatings which are more resistant to oxidation, corrosion, and stress corrosion cracking. The losses to the Federal Government due to oxidation and corrosion have been estimated as high as a billion dollars annually.

This new effort is already providing regular inputs to AFSC's Air Force Materials Laboratory program to develop new, high-temperature, refractory structural materials, and is also relevant to the development of carbon and carbide fibers for advanced materials. Other research efforts within the ceramics program, dealing with the electronic, optical, and thermal properties of ceramics, are being reoriented to support the new effort with an interdisciplinary approach.

The very nature of the Air Force mission requires that all weapon systems operate within the aerospace environment and in this area research management gets involved not only in basic environmental research, but also in the exploratory and development research areas. OAR is responsible for all Air Force research in the environmental sciences which includes geology, geodesy, meteorology, upper atmosphere chemistry and dynamics, solar phenomena, and environmental properties of near space.

In order to conduct experiments in the atmosphere, it has been necessary that satellites, balloons and rockets and special instrumentation be designed, developed, and launched. OAR is one of the world's largest users of sounding rockets and balloons. Special fabrics have been designed for large research balloons and launching techniques perfected that have made it possible to launch 28-million-cubic foot balloons to an altitude of 160,000 feet. Balloons have been designed that can be recovered and used again. We have launched tethered balloons to an altitude of 10,000 feet and our goal is 100,000 feet. Balloons offer an economical method of getting a scientific payload to altitude. We presently can lift a 10,000-pound payload to 70,000 feet, and a 2,000-pound to 130,000 feet.

To date OAR personnel have launched over 375 scientific payloads aboard Scout, Cajun, Nike, and other sounding rockets as well as 7 deep space probes and 33 piggyback scientific passenger pods. In addition 40 plus satellites in support of research in the aerospace environment have been orbited and have provided vast amounts of new knowledge of the aerospace environment.

Every day research scientists learn a little more, always looking for the big breakthrough, but more often gaining new knowledge in small bits which combine and fit together in bigger pieces until the big breakthrough occurs. Management must realize that quality research usually cannot be hurried and breakthroughs cannot be directed. The business of understanding physical phenomena is an elusive process. There must be a certain amount of wandering along the boundaries of knowledge in the hope of learning some new phenomena.

Modern science is getting much too big and complicated for any one man in any one discipline to grasp completely. Critical research problems refuse to fall into neat disciplinary categories. In order to solve complex technical problems, the Air Force for many years has been conducting interdisciplinary research. Research managers will continue efforts which will lead toward more interdisciplinary research. However, at the same time, single disciplinary research must and will continue to flourish and will never be replaced by interdisciplinary research. The loner, the creative genius who works within his own isolated laboratory is definitely needed.

We in OAR believe we are doing a good job of research management, but we also believe there is always room for improvement. Therefore, to further enhance the capabilities of managing our resources, we have recently established a management research team. This team, which will perform basic and applied research in the resources management field, will hopefully be able to develop new techniques and methodologies that can be applied to the research community. We envision that through this type of research OAR, as well as other research agencies, will be able to increase its effectiveness and efficiency in performing research functions.

Army Engineer Budget Reduced in FY 1970 Revision

A $142 million reduction has been made in the Army Corps of Engineers' budget request for FY 1970. The Engineers' Civil Works program amounted to $1,020,135,000 in the President's revised budget, down from the $1,162,000,000 in the original budget submitted.

Changes made in the budget request included an increase of $500,000 for General Investigations, to provide funds for a Lower Mississippi Region comprehensive study, and a decrease of $142,365,000 in the Construction, General appropriation.

Eight new planning starts were added to the budget and four deleted, and a major rehabilitation project for the John Hollis Bankhead Lock and Dam, Ala., was added.

Designing an Integrated Logistic System

Brigadier General George C. Axtell, USMC

Integrated logistic support is inescapable. It always was. We are now more conscious of the process because all of the elements of support have been identified, and a formal systems approach to weapon support has been taken. Integrated logistic support (ILS) had to evolve because the sheer complexity of hardware demanded it. Now that it is here, officially and formally, and working, there seems to be something missing. ILS does an amazing job of integrating the requirements of the logistician with those of the equipment designer and operator. There remains, nevertheless, a problem of placing an item of equipment in service and keeping it supported—ILS or no ILS.

When equipments are placed in service, they must be supported by the Military Service's logistic support system. Decisions to buy parts, tools, publications and other items, as well as to distribute them, are made on the basis of each Military Service's support system. The result of this is that ILS decisions are influenced by the configuration of the logistic system in which the new equipment is to live. Are these systems adequate? Is there a deeper integration process that suggests more harmony and coherence between the elements of the system—prior to consideration of hardware decisions? These questions form the framework for this article.

For orientation purposes, answers to the posed questions are views expressed by Marine Corps logisticians. This, in turn, demands an appreciation of how a marine sees the process of logistic support from the national level. These views, observations and conclusions are expressed herein—not for the express purpose of suggesting that they be adopted, but rather to convince others that there very well may be an area of considerable potential for exploration.

G–4 Tasks in the Marine Corps

The Chief of each of the Military Services is responsible for the total logistic capability of his organization

to carry out whatever mission may be assigned in the national interest. The role of the Assistant Chief of Staff, G–4, the logistics officer of the Marine Corps, is that of the temporary custodian or trustee of the following tasks:

- To assure that the individuals, the units in the operating forces, the divisions, the aircraft wings, the combat support units, all obtain what they need.
- To propose and secure adoption of, in an evolutionary approach, that organization required to support these units, including the optimum maintenance and supply systems.
- To translate operational requirements into those directives and actions required to support the technical side of the research and development effort.
- To collect, assimilate and correlate information required to justify the resources needed for the procurement of equipment, and the funds required to operate and maintain the operating units.
- To audit the system in order to determine performance, anticipate problems, and seek solutions to deficiencies, whether they be managerial, technical, or other.

The Assistant Chief of Staff, G–4, as the advocate in Washington, D.C., for the consumer (the man in the field), has as his basic tools to accomplish the foregoing functions those of a manager in the most general sense: motivation of people, stimulation of ideas, keeping lines of communication open. In trying to keep the logistic organization of the Marine Corps oiled and operating, he must insure that resources are allocated in those areas where analysis indicates there will be a payoff in support capability.

All logisticians in the Military Services are cognizant of the need to field supportable weapons and to plan for their continued uninterrupted support, so as to insure a high level of operational readiness. There appears to be an incipient problem, however, in placing such precisely designed and supported weapons in service. Descriptors to identify the problem are difficult to devise. Perhaps the best representation of the impediment is to describe the process as one of placing weapons and equipments that *individually* have a highly disciplined support package into what appears to be an *undisciplined* logistic support system. As an explanation of this: the ILS process is a highly disciplined methodology for getting hardware into use and for keeping it useful for its life cycle. It is highly disciplined because it precisely charts the life cycle of an item of equipment, starting with concept formulation and finishing with retirement from service of the equipment, as well as describing the events that take place during sub-phases of the cycle.

Many Aspects of Logistic Support

On the other hand, the logistic support system can be described as a conglomerate of organizations, personnel, facilities and procedures necessary to provide the required logistic support. It includes supply, maintenance, transportation, medical and other routines, with many information networks—the bailing wire for keeping it together. The system is grossly lacking in the "harmony and coherence of its elements" that is typified by ILS. This is natural, since a number of co-equal activities, such as the business world, civilian transportation agencies, and the several agencies of the Defense Department, play significant roles in the total cycle. The logistic support system does not need a czar to rule it; it does require a capability to have a meaningful visibility of the total effort.

It is highly essential that logisticians establish and agree on a meaningful description of what a logistic support system *should do*. It is only in this manner that its performance and effectiveness can be measured. It is here we begin to gain some appreciation of the vastness, and the apparent vagueness, of logistics. Logistics means many things to many people. It is procurement; it is supply, it is maintenance, transportation and medical; it is all of these things and a myriad of others. As a matter of fact, a complete logistic support system, as a system, defies adequate identification except when related to the key word, SUPPORT. First, it is necessary to describe what is to be supported, including the array of environmental settings in which some specific group or task force of organizations, with their organic weapons, is to operate.

In describing the performance requirements of a logistic support system, the concepts of ILS may prove applicable to the software package (the entire logistic network needed by a Military Service to enable it to develop, produce, fight and sustain the equipment and weapons it is required to support).

At this point, it is prudent to briefly review ILS. ILS is ". . . a composite of elements necessary to assure the effective and economical support of a system or equipment at all levels of maintenance for its programmed life cycle." It has enabed logisticians to communicate with design engineers.

What Can ILS Do for the Manager?

ILS can provide the basis for the manager to tailor management planning of specific tasks, at the appropriate level of detail, for logistic support planning and integration. The looked-for end result is to insure that management actions integrate all support elements in order to maximize the availability of equipment and optimize support costs. Why cannot this same methodology work for the logistic support system as it works for hardware? An examination of the 10

Brigadier General George C. Axtell, USMC, is Assistant Chief of Staff, G–4, Headquarters, U. S. Marine Corps. Immediate previous assignments include Commander, Force Logistics Command, Fleet Marine Force, located in the Republic of Vietnam; and Chief of Staff, III Marine Amphibious Force. General Axtell holds LLB and MA degrees from George Washington University, and is a graduate of the National War College.

elements of support (maintainability and reliability, maintenance planning, support and test equipment, supply support, transportation and handling, technical data, facilities, personnel and training, funding, and management data) described in ILS reveals that they comprise most of the common basic elements of the total logistic support arrangement. ILS calls the support elements "things to manage." Some of these "things to manage" are supply support, maintenance planning, personnel and training, and transportation. These four of the ILS support elements were selected here to illustrate the point that these elements are all parts of a support package for a piece of hardware.

Each of the Services has developed its own supply operation, its own maintenance organization, its personnel support system, to some extent its internal transportation network, all of which fill a peculiar requirement to respond to the particular Service's ultimate objective of supporting an operational demand.

It is not expected that the logistic support systems of all the Services will be configured the same way; this is neither feasible nor desirable. For instance, the Marine Corps places heavy emphasis on the embarkation process to facilitate debarkation for the forceful entry of a landing force into a hostile area ashore from its seaborne base. This is not "called out" in ILS. However, the Marine Corps must consider the embarkation/debarkation process and treat these elements as part of the Marine Corps logistic support system. It is obvious that industry and the other Military Services have different peculiar elements that comprise a specific routine. Nevertheless, ILS has identified the 10 essential support elements which should be managed in relationship to a hardware program. As examples, the "supply support element" is managed in a supply organization; the "maintenance planning element," in a maintenance hierarchy.

It is now the job of the Marine Corps how best to design, for example, our amphibious supply system, our peculiar maintenance organization, our specialized embarkation process, and put these various routines together in a composite system package, and treat this package as a "total logistic support system."

What is the purpose, the advantage of accomplishing the foregoing task? Why do we want to do this? For the identical reason which has been stressed by the disciplines of ILS: to achieve a level of harmony and coherence between all of the elements of the system. Our supply scheme must relate to our maintenance concept; our logistic support personnel must be structured in organizations that tolerate fracturing or task organizing to accommodate a selected groupment of combat units for a specific mission. An independent development of a supply system, as an illustration, cannot be tolerated because the Marine Corps might not be willing to pay for a constraint it could place on tactical mobility. Because ILS is achieving the harmony and coherence of support elements, we should endeavor to see how this is accomplished and ascertain if the methodology is applicable to the logistic support system package.

Support of Amphibious Warfare

The following approach appears to be the most practicable and productive. First, there must be a description of what a logistic support system should do. We must be able to identify the contribution which logistics in its totality is required to make in support of amphibious warfare, *i.e.*, the logistic concept. The organization and methodology for the tactical application in support of an amphibious force deploying on an operation is well documented. We do not desire to design a logistic support system unto itself; it must satisfy a requirement and be responsive to something. The "requirement" and the "something" in the case of the Marine Corps is amphibious warfare.

At the outset, however, there must be a description of amphibious warfare. In looking at concepts of warfare, amphibious warfare as far as the Marine Corps is concerned, we find many elements that vary the concepts. For example, there are modes of assault, surface or vertical, and combinations thereof; there are environmental factors, such as would be found in operating over open beaches, operating close to the seashore, or those requiring a deep penetration inland. Further, we find a variety of postulated tasks, such as seize and hold, patrol and block, raid and destroy, and several others. Also, the Fleet Marine Force, in accord with the statute, must be prepared to perform any mission which the President may direct, in addition to the classic amphibious assault mission.

Without attempting to influence the modes, environments and tasks of amphibious warfare (and our function, logistically speaking, is not to influence, but to be responsive), we can indubitably develop from these assumptions a "logistic system concept." This would be an extremely broad set of logistic support objectives designed to match the concepts of warfare. It would be similar to the concept formulation phase for a new weapon. Further, it is the same technique used in the ILS process, wherein the logistician talks to the design engineer, except here the logistician is utilizing that very discipline in his contacts with the operational commander.

With an amphibious warfare concept paper and a companion logistic system concept document that is structured on the basis of supporting a concept of warfare which takes on many images, it is, or should be, a relatively easy undertaking to proceed with system developmental action as suggested by ILS. The logistic system concept phase has already been equated with the concept formulation phase. A "logistic system specification" is acquired to define precisely what is required of a maintenance organization, a transportation scheme, a command and control system. This could be likened to the contract definition phase in hardware development procedures.

So far, three phases in the logistic system development process have been identified. It is critically important that these phases, and those that follow, be integrated; *i.e.*, the products of each phase should be used to validate the actions before that stage and to provide direction to subsequent ones. Further, personnel responsible for one phase must be afforded the opportunity to participate actively in other phases. This is one of the key issues involved in ILS.

In engineering a logistic support system, the next phase is the development portion. This is equatable to the normal weapon development phase. In this realm we can establish exactly what is needed in the logistic support system and how the changes are to be made. The normal weapon

production phase can be called the logistic system modification phase. Although this is not a true production phase, the authorized changes to the logistic system which are being effected are synonymous with production. The final phase in readying a logistic support system is its operational feature. As we do with our weapons, we must maintain constant watch on our total system performance and feed performance data back to the designers and, above all, to the operational commanders responsible for execution of the warfare mission.

Sixth Phase—Warfare Concept Definition

The foregoing is a depiction in rather brief form of a conceptual link between the phases of weapon system design, development, and production, and the design of a logistic support system. Our weapons are assured of the proper management during the development and operational stages. It is not at all certain that the same degree of attention is provided our support systems.

These formulations applied the five life-cycle phases of hardware to the software problem. Also, it has been suggested that the same anaytical approach should be taken to solve the apparent disorder in logistic systems. A sixth element can be added, one which precedes all others; this is the warfare concept definition phase. For clarity, a recapitulation of this process is inserted here.

The logistics support system should be designed after an in-depth analysis of the warfare concept. It is only after this analysis has been made that specific logistical needs are identified and provided. Following the weapon life-cycle phases we, then, have the following tasks to complete:

- In lieu of concept formulation, develop a logistic system concept; this will be the architect's pencil sketch of the system, with details to be worked out later.
- In lieu of contract definition, develop a logistic system specification; here we introduce a degree of precision in what is required, and start to fill in details of performance and of the aims of the system.
- Proceed with the logistic development phase by applying the principles of the weapon system development phase; we are now attaining increased precision, and are developing specific production prints as to what the system is to accomplish and how it is to operate in accordance with identified procedures.
- Substitute the logistic system modification phase for equipment production; at this point we actually make changes incrementally in the system, as fast as personnel can be trained and managers converted to the new philosophy or cult, by installing a new maintenance routine, a data network, a modified supply system, etc.
- Retain the normal equipment operational phase; however, we must monitor and audit the performance of this universe rather than the hardware.

If this process just described is to gain acceptance, it must contain significant tangible payoffs. They appear to be there. For illustration purposes, it is difficult to conceive that a maintenance concept can be designed without attendant identification of what the tolerances for maintenance in any selected warfare mode would or should be. Additionally, there is the problem of how to identify the tradeoff that can be made in a supply system on the basis of alternative maintenance schemes. How can a logistic study program be conducted without full knowledge of the objective of a total logistic support system? Many more questions could be asked that caution against taking small bites at our logistic system deficiencies and against developing fixes which are resolving only minor difficulties. It all sums up to the requirement for the Marine Corps to remain conscious of the in-house need to have someone responsible for watching and scheduling the complete system design.

The ultimate results of a systems engineering approach to our logistic system, regarding all of its parts related to a common objective, should accomplish the very same thing that ILS has done for equipments. This is an unusually simple objective and can be paraphrased from the definition of ILS. It will "provide harmony and coherence" of the logistic system elements. It will balance the need for change to any part of this logistic universe, with full consideration being given to the effects of the change on other parts of the system. Above all, it will consider our capability and capacity to change. For example, a new supply arrangement will not make a contribution until there exists a demonstrated and proven case that the new methodology is absorbable. This refers to the ability of the personnel who will use the system to understand what it is and how it is supposed to function, from the private up to the general, with emphasis on the general.

The process herein described appears to offer an exploitable opportunity for logisticians to look macroscopically at what they are responsible for. We must be able to motivate ourselves into taking a broad look at our systems and seek an objective discipline to our approach to change. There is, fortunately, a rather plain and unsophisticated objective. The logistician should identify the postulated warfare concepts to determine their impact on his role, then develop a series of logistic support concepts and plans and, lastly, identify the resources which are required to support the plans.

Too much emphasis cannot be placed on the fact that operational commanders must be furnished logistic support options. With the various modes of warfare, warfare tasks and environments incumbent on the Marine Corps, no single system is going to be optimum for all. We must have alternative and redundant systems ready to offer.

Something for all of us to remember, even logisticians, is exemplified by an excerpt, amphibious warfare oriented, from the diary of General Sir Ian Hamilton at Gallipoli in April 1915.

> **. . . At home they are carefully totting up figures—I know them —and explaining to the P.M. and the senior wranglers with some complacency that the 60,000 effective bayonets left me are enough —seeing they are British—to overthrow the Turkish Empire. So they would be if I had that number, or anything like it, for my line of battle. But what are the facts? Exactly one half of my "bayonets" spend the whole night carrying water, ammunition and supplies between the beach and the firing line. The other half of my "bayonets", those left in the firing line, are up the whole night armed mostly with spades digging desperately into the earth. Now and then there is a hell of a fight, but that is incidental and a relief.**

(Continued on page 44)

System/Cost Effectiveness Analysis in the System Engineering Process

Colonel Donald H. Heaton, USAF

The increasing cost and complexity of today's weapon systems to fulfill military missions have brought into sharp perspective the need for a system discipline, capable of providing for total systems tradeoffs and greater visibility to management through integration of system engineering requirements. A general recognition of this need led the Air Force Systems Command to establish the Weapon System Evaluation Industry Advisory Committee (WSEIAC) in 1963. Summarily, the objectives of the WSEIAC were to review the current state of the art of system/cost effectiveness analysis, develop proper foundations for system/cost effectiveness concepts and, in general, to make recommendations pertinent to the technological needs of the discipline. The WSEIAC report has served as the foundation for our system/cost effectiveness activity since its publication in 1965.

In the Air Force Systems Command, we view system effectiveness analysis as an integral part of the system engineering process for managing the technical definition of a system and the technical program for its design, development, test and evaluation. System engineering is the engineering planning and control process which insures the completeness, integrity and optimization on a complete system basis of the definition products, consisting of performance specifications for the system and plans for all elements of the development, test and evaluation program. Specifically system effectiveness analysis aids the evaluation process of system engineering to determine the optimum choice among technically feasible alternatives from a mission performance point of view. Cost effectiveness analysis, then, is the companion technique for relating total system effectiveness to life-cycle cost. In essence, the combination of system and cost effectiveness analysis is the "heart" of the system engineering design optimization process. We have established this role for system/cost effectiveness in a new military standard for System Engineering Management. This standard is a part of the DOD System Engineering Management Project, recently initiated by the Director of Defense Research and Engineering, and is being developed by the Air Force in a "lead Service" role.

System effectiveness is a quantitative measure of the extent to which a system may be expected to achieve a set of specific mission requirements. The WSEIAC suggested that effectiveness be expressed in terms of a figure of merit, a measure of effectiveness in the form of a simple statement of mission objectives to which quantitative system requirements can be related. Some examples of such figures of merit are probability of success for a single sortie, ton miles/year, or number missiles on target per squadron per strike.

The WSEIAC further concluded that system effectiveness is a function of system *availability, dependability* and *capability*. This concept is altogether valid. It is an excellent framework around which to develop an analysis which encompasses the entire problem of operational and support effectiveness. The analysis must consider all those system characteristics that impact these system attributes.

Simply stated, capability represents the mission performance of the system in its natural and combat environment if all subsystems function to then specified values.

Availability is what the word implies: the state of operational readiness of a system when called for a mission. For an aeronautical system, for example, availability is obviously a function of the condition in which an aircraft returned from its last mission or whether it returned at all. This state depends largely on the reliability of its elements and its survivability in the enemy environment. Given a particular state on return, its availability for the next mission further depends on aircraft maintainability and the support subsystem characteristics, such as the supply and placement of spare parts, ground support equipment and maintenance skills and, of course, the time before next mission call-up.

Dependability, then, completes the picture, by contributing the likelihood that a system, once available, will perform up to its specification level, *i.e.*, up to its capability. It is largely a function of reliability and in-flight maintainability, if provided. Thus, availability, dependability and capability provide the framework for

Colonel Donald H. Heaton, USAF, is Assistant for Management Systems in the Office of Deputy Chief of Staff/Systems, Headquarters, Air Force Systems Command. He was previously Deputy Commander for Manned Space Systems of AFSC's Space Division, and has served in various liaison positions with NASA. Colonel Heaton is a graduate of West Point, and holds a masters degree in mechanical engineering from Rensselaer Polytechnic Institute.

determining the interrelated impact on figures of merit of all technically achievable system characteristics, and for enabling the identification of best or optimum combinations, each of which has associated with it a set of life-cycle costs.

Similarly stated, cost effectiveness is a measure of the value received (effectiveness) for resources expended (cost). Cost effectiveness has, unfortunately, taken on an aura of economy first, military effectiveness last; rationalization or procrastination in the initiation of needed new systems; and penny-wise, dollar-foolish decisions in general. Despite such bad press, cost effectiveness is an analytical tool, indispensable in today's world of enormous defense costs and technically complex, interrelated systems. It can be misused; however, it need not be.

Properly employed, system effectiveness analysis is first applied to identify preferred combinations of characteristics of the capability type, which will not preclude subsequent optimization on the basis of all system effectiveness characteristics and cost. The analysis next is extended to include the availability and dependability parameters, and life-cycle cost analysis is applied to identify the total program costs associated with each combination. The optimum combinations, obviously, must be identified from the results of both analyses.

Both system effectiveness and cost effectiveness analyses make use of analytical models to mathematically represent the system being analyzed, its operating characteristics, and the concepts of its tactical operation and support. These models are normally structured so that any parameter, or combination of parameters, can be varied to determine the relative effect on total system performance (effectiveness) and life-cycle cost. Generally, these models are computerized. This is a necessity for complex systems due to the large number of variables and large quantity of data involved.

Admittedly, system/cost effectiveness analysis has limitations attributable to its system effectiveness and cost analysis components. Perhaps the most pervasive limitation is in our ability to accurately forecast the effort (and, therefore, the cost) required to achieve a set of specified system characteristics in a developed product. A further limitation is our inability to link the support actions and costs of systems, subsystems and equipment in a way which will enable dependable extrapolations of this experience to set design goals for the support characteristics of new systems.

Another particularly troublesome limitation is in predicting the enemy environment (threat) consisting of weapons, strategy and tasks with which our combat systems, and especially our manned systems, must cope. In such cases the capability factor is far from precisely determinable, and yet it is vitally important since a second-best combat system is not a very effective system. These limitations result from a combination of shortages in data and our inability to construct models truly representing the features of a future "real world" which should drive design and program emphasis.

However, each of these limitations is subject to reduction through deliberate effort. One of the best ways to develop such an evaluation tool is by applying it to programs, using great care to attribute only such confidence to its answers as is warranted after analyses to determine program limitations in a given case. Such an analysis estimates the margin of error in the values and relationships involved in an application, determines the sensitivity of conclusions to these values and relationships, and determines whether the potential errors can alter the conclusions reached from applying the process.

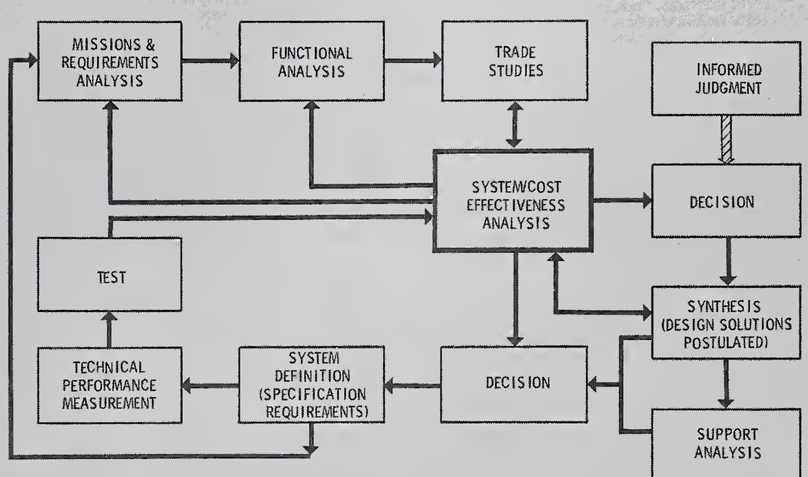
Because of such limitations, system/cost effectiveness analysis should be used as an aid to decision making. It should never replace judgment. It is, however, a potentially invaluable evaluation tool for the decision maker throughout the life cycle of a system. The analysis must be attuned to support the decisions that have to be made during the various phases of system development and production.

Conceptual Phase

System definition during the conceptual phase is properly devoted primarily to the identification of performance features for optimum system capability, such as payload, speed, navigational accuracy, radar range, etc. Correspondingly, system effectiveness analysis during the conceptual phase principally supports the capability optimization process. In determining systems capability parameters, system planning must seek to avoid precluding the later determination and achievement of optimum values of reliability, maintainability, and other design performance features which govern system dependability and availability.

Also during this phase, operational and logistic concepts and data should be developed from which system effectiveness and life-cycle cost models can be constructed for subsequent use in engineering development which encompass all three ingredients of total system effectiveness—availability, dependability and capability.

SYSTEM ENGINEERING PROCESS



These models should preferably be provided to the contractors, competing for engineering development contracts, with instructions that they be further developed and employed in determining the quantitative values to be proposed for development specifications, and the planning of program effort.

At the very least, sufficient guidelines and data should be provided to contractors for their development of models to optimize the dependability and availability features and specification values to be included in their proposals. To do so requires that, during the conceptual phase, the operational concept for the system be developed and, in turn, the logistic support concept be derived and sufficient program planning accomplished to provide a basis for the development of life-cycle cost estimates. The determination of firm quantitative values of system and subsystem reliability and maintainability, and other measures of logistic supportability, plus the specifics of the test effort to demonstrate these qualities, should be left for the contract definition phase; or if a definition phase is not carried out, then in the course of early engineering development.

One of the most important contributions the conceptual phase can make to system availability and dependability is to assure that total acquisition program costs are projected, to include as valid estimates as can be developed of the effort necessary to define, attain and demonstrate availability and dependability. It is a fact that in no systems to date have system availability and dependability competed technically with capability for influence on design performance features. However, it is entirely possible, and even desirable, that these qualities should compete technically subject, of course, to performance, physical cost and schedule constraints which are "givens" in the optimization process following engineering development program approval.

In the real world to date, the competition has been for development, test and production program dollars, largely because initial program cost estimates failed adequately to foresee the size of the job ahead to provide a system with not only promised capability, but also with availability and dependability representing cost effectiveness on a complete system life-cycle cost basis. Correction of this imbalance is a major purpose of the Air Force efforts to include cost effectiveness analysis as a tool in system and program decision making. It is also one of the primary reasons for integrated logistic support as a planning and acquisition program requirement.

Definition Phase

One purpose of the definition phase is to define the system and acquisition effort in sufficient detail to support a prudent commitment by Government and contractors to enter into whatever type of contract, *i.e.*, development, test and evaluation, or development plus production, is contemplated. A second purpose is to select the competing (or sole source) contractors who will conduct the first step of hardware development, beyond conceptual phase activity leading toward an operational system.

Ideally, contractors will be provided system and life-cycle cost models, representing the mission or mission mix and relating system performance and physical characteristics to figures of merit for the system. As stated before, system constraints will be of the capability type. Availability and dependability, and some capability parameters, will be dependent variables to be optimized by contractors using the models they were provided to the extent they are useful. Contractors will expand the models to represent their proposed system designs. The models and the system specification which they receive with the request for proposal will be baselined, *i.e.*, subjected to configuration control by the Government. However, any time in the course of further definition and allocation of performance requirements below the system level a contractor determines that either the model or specification does not truly reflect announced government program goals, he is urged to propose a change with suitable justification. If his proposal is accepted, the change will be applied to all competing contractors.

Contractor proposals will contain firm specification values for all availability, dependability and capability parameters for which values were not provided in the request for proposal. These values should be the products of life-cycle cost effectiveness optimization of alternative values arrived at through application of a system engineering process which satisfies the MIL-Standard (now a draft) on System Engineering Management.

Decisions among open capability alternatives require finer distinction than those made in the conceptual phase. In fact in some cases, especially for manned, multiple-mission combat systems, the "model gap" referred to herein will not provide a completely reliable analytical basis for validating the system performance and physical requirements decided on in the conceptual phase. The modeling deficiency, in such cases, will be in relating system performance parameters to figures of merit, so that the figures of merit are sufficiently sensitive to variations in the parameters to be of particular value in source selection or in the application of performance incentives. Even when this relationship between system figures of merit and system performance is of questionable utility in validating such values, models for the allocation of these values to subsystems and components are within the state of the art. As we shall see, such "parameter dependency relationships" are useful in determining the seriousness of technical deficiencies which occur in the course of the program.

We are usually better off in the optimization of availability and dependability parameters than of capability parameters. For one thing, increased reliability and maintainability will always enhance system effectiveness, until the technical measures required to achieve the increased levels begin adversely to impact system capability. (As stated previously, I know of no case where this has happened, but it could.) The same is not true, however, for cost effectiveness. Cost tradeoffs must be made between higher development and unit production costs on one hand, and operational phase logistic support savings on the other. This situation is quite amenable to cost effectiveness analysis.

In this phase of system development, the contractors can be expected willingly to use cost effectiveness techniques since they represent not only an overall effectiveness requirement, but the government's desire for increasing performance while reduc-

ing cost. This is strongly reinforced by the fact that the contractors are normally in a competitive environment.

Acquisition Phase

Ideally, all elements of the system would be described in terms of performance specifications during the conceptual and definition phase, *i.e.*, before the development contracts are awarded and, in Air Force parlance, the acquisition phase begins. If this were practical, our development contracts would represent a complete meeting of the minds between Government and contractors on the performance and key physical characteristics of all of the products to be developed.

It is, unfortunately, not practical to define these "design-to" and "test-to" operations for all elements of the system before development is begun due to the sequential nature of the process. For example, the requirements for ground equipment and training programs depend upon the details of the solution to the design problem presented by prime equipment performance specifications, and these solutions are products of the development program. Therefore, the new system engineering management standard requires that system and cost effectiveness analysis be employed to aid in the optimization of the system design requirements and program planning which, of course, goes on during acquisition. The use of system and cost effectiveness analysis is not only required by the new standard to complete the optimization of the system as initially defined; it is also to be employed in the planning and selection of the engineering and technical program changes which are proposed during the course of the acquisition program. These are the types of changes required to overcome or work around technical problems or funding limitations, to adjust to changes in the military problem, to turn new technological possibilities to advantage in terms of increased mission effectiveness, or to accomplish net reductions in life-cycle cost.

Finally, during acquisition, one of the byproducts of system and cost effectiveness analysis enhances the fidelity and timeliness of Technical Performance Measurement (TPM). TPM is a new set of words to describe an element indispensable to engineering and program management. The System Engineering Management Standard merely sets a standard of contractor performance of this element of engineering management. TPM is nothing more than the design assessment function carried out through test and engineering analysis. TPM does not include the identification of the possible cures and the choice among them—the use of cost effectiveness analysis to help in this optimization process described in the preceding paragraph. In TPM, it is the existence of the parameter dependency relationships during the initial definition of systems requirements which comes in handy. The System Engineering Management Standard requires that contractors know at all times when a technical variance is occurring at all levels of design that will impact contractually specified requirements. Parameter dependency relationship enables a quantitative impact by such anomalies, on system level performance parameters and on system figures of merit, to be quickly and accurately determined.

Two other important facets of the application of cost effectiveness analysis during acquisition called for in the System Engineering Management Standard must be understood. One is the statement that this optimization tool should be used only to the extent it can "cost effectively" contribute to a particular decision. Simple decisions should not employ unnecessarily complicated or sophisticated evaluation methods. We do not want to create a supercult in system engineering management or in its cost effectiveness ingredient. However, the existence and probable implementation of comprehensive computerized system effectiveness and life-cycle cost models can forestall the costly sub-optimization which often results from too shallow an analysis or "horse back guesses."

The second point has to do with the fact that the powerful incentive of competition is lost when acquisition contracts are awarded. During the competitive source selection phase, as discussed before, contractors are motivated to outdo themselves to give us what we want, and one elequent way of doing this is through effectiveness and cost models. However, with the advent of the acquisition phase, the scene changes. Now contractors are motivated to minimize their risks and maximize profits under their contracts. Contractors will develop profit models and use them in the decisions which are within their prerogatives. It is entirely possible that a profit model will identify a decision which is "optimum" for a profit point of view, but which is in conflict with government interests as indicated by the use of system effectiveness and the life-cycle cost analysis. The System Engineering Management Standard recognizes this real-world possibility, and requires the contractor to advise the Government of any such conflicts which occur between contractor interests under the contract and government interests as revealed by system and cost effectiveness analysis. This will afford the procuring agency an opportunity to reassess its requirements and possibly pre-empt the contractor's decision. Obviously, when the procuring agency chooses this option, it must be prepared to accept whatever reduction in contractor responsibility follows as a consequence under the terms of the contract. Certainly, it is in the best interest of the Government to have this flexibility.

Operational Phase

Historically, we have always been faced with decisions relative to new or revised system usages (missions) and hardware modifications after the system becomes operational. For this reason, system/cost effectiveness analysis should be continued and models maintained into the operational phase. They will be most useful in making these decisions.

In summary, system/cost effectiveness analysis is considered to be a discipline with a real future. Its selective application to new programs is justifiable by its potential for improving the validity of program decisions and the efficiency of our decision-making process, plus the fact that only through application can we assess and overcome its limitations as an instrument to assist in rational decision making. Yes, we have problems, not the least of which is the acceptance of the discipline by some of our engineers and managers, and the shortage of qualified personnel to support the analytical process. We are devoting a growing portion of our resources to overcome such problems and, in time, I am convinced we will have them resolved.

MIL-STD-785A

Revised Standard Establishes Requirements for Reliability

George S. Peratino

Early in the 1960 decade, the need for mission responsive military systems and equipment brought about the development of Defense Department policy that would assure the development and production of reliable weapon systems.

Following the issuance of DOD policy, the Military Departments initiated procurements, including numerical reliability requirements and provisions for demonstrating attainment of the reliability. This required the preparation and submission by industry of proposed reliability program plans when responding to Requests for Proposals. To avoid the submission of individual creativity in the reliability programs received from each bidder, DOD appointed a departmental task group to develop a military standard for guidance in the preparation of reliability program plans. The DOD task group developed and obtained major military commands' approvals of MIL-STD-785, "Requirements for Reliability Program(for Systems and Equipment)." Industry association comments were also solicited and considered in the preparation of the final version of the standard, and MIL-STD-785 became effective on June 30, 1965.

The application of this embryonic standard by industry was met with mixed emotions. This prompted the re-establishment of the DOD task group for development of a revision to the existing standard that would be favorably accepted by industry. Initially, the task group explored areas of weakness and controversy in MIL-STD-785. Preparation of a proposed draft revision resulted that was circulated to all major commands of the Military Departments for comment and/or approval. After review of the major command comments, a new draft of the revision was prepared.

On Oct. 10, 1968, the draft revision was submitted to the Electronic Industries Association (EIA) and the Aerospace Industries Association (AIA) for review and comment. EIA and AIA comments were received by mid-December 1968. The final draft of MIL-STD-785A has been approved by the Office of the Director of Defense Research and Engineering, and is now available from the Naval Publications and Forms Center, Philadelphia.

Provisions of the Standard

Major points of interest to those affected by the provisions of MIL-STD-785A are:

- The standard is applicable to all DOD procurements. In addition, it shall be utilized on government in-house development and production of systems and equipment.
- Each contractor is required to establish and maintain an effective reliability program to permit the most economical achievement of overall program objectives. The program shall assure reliability involvement throughout all aspects of the design, development and production to meet the contractual reliability requirements.
- Mission responsive reliability requirements and objectives of the system/equipment shall be specified contractually. Quantitative hardware reliability requirements for all major subsystems and equipments shall be included in appropriate sections of the system and end item specifications.
- Achievements of minimum acceptable hardware reliability requirements shall be demonstrated by means of tests and analyses as required by the contract.
- The reliability program shall be coordinated with other interfacing efforts, such as maintainability, human resources, safety, quality assurance, standardization, systems engineering, configuration management, and integrated logistic support, to assure an integrated and effective contractual effort.
- The reliability program plan shall stipulate methods for assuring that the subcontractor's and supplier's reliability efforts are consistent with overall system requirements. Provisions are made for source selection of subcontractors and suppliers, and surveillance of their reliability activities.
- A reliability analysis of the system/equipment shall be initiated at the start of the contractual effort. This analysis should be an integral part of the overall system/equipment analysis which is conducted to obtain a balance between effectiveness, schedule and total resources. The standard contains a suggested approach for conduct of the reliability analysis.
- Parts which are described in military specifications, having established quantative reliability requirements (failure rate levels), shall be used whenever possible. Parts application criteria shall be established to control

George S. Peratino serves as Assistant for Reliability Matters in the Directorate of Procurement Policy, Office of the Deputy Chief of Staff (Systems and Logistics), Headquarters, U. S. Air Force. He is responsible for the development and implementation of Air Force reliability policy and management procedures to attain mission responsive weapon systems. Mr. Peratino holds a B.S. degree in electrical engineering from the University of Maryland.

selection of parts. The best available estimate of a reliability index, under the applicable stress levels, shall be assigned to each part, component, or subassembly. Available data and central information facilities shall be utilized to avoid needless duplication of testing.

• A failure mode and effect analysis shall be performed to identify potential system weaknesses. Each potential failure shall be evaluated to determine its effect on mission accomplishment and ranked as to its criticality. Mission critical failures shall be further investigated as to failure mode to determine design improvements required for elimination of failure causes or reduction of risks to acceptable levels.

• Reliability critical items are those items, the failure of which significantly affect the ability of the prime item or system to perform its overall function. The contractor shall establish a program for identification, control, and special handling of critical parts, components, subsystems, or other items from design through final acceptance.

• Reliability design reviews shall be conducted at appropriate stages of development and production to evaluate achievement of the reliability requirements.

• An integrated test and demonstration plan shall be prepared and submitted for approval by the procuring agency. The test plans contained in MIL–STD–781, when applicable, shall be applied. The test program shall be integrated with other system/management tests to avoid costly duplicate testing.

• Functional environmental testing shall be conducted during design and development phases to estimate achieved reliability and to provide feedback of data as a basis for making reliability improvements.

• The contractor must have and shall require subcontractors also to have a closed loop system for collecting and analyzing all failures that occur during in-plant tests, and those that occur at installation or test sites prior to turnover to the procuring agency. The failure reporting system shall be compatible with the procuring activity data collection system so that as the system nears the operational inventory phase, transition to in-service failure reporting can be accomplished with minimum disturbance and maximum continuity of effort.

• For reprocurements of systems/equipments, the procuring agency shall specify the minimum acceptable reliability requirements and appropriate demonstration requirement, and indicate those reliability program elements of MIL–STD–785A applicable to the specific procurements.

Actions by Military Services

Air Force reliability policy is contained in Air Force Regulation 80–5, "Reliability and Maintainability Programs for Systems, Subsystems, Equipment and Munitions," which has been revised to incorporate provisions for applying the requirements of MIL–STD–785A. The Air Force Systems Command (AFSC) is responsible for determining the scope of reliability and maintainability programs necessary to achieve system equipment requirements. AFSC must specify the program elements from MIL–STD–785 and MIL–STD–470 that the contractor must include in his program plans or response to the Request for Proposal.

The Navy policy for reliability of Naval material was initially established in January 1966 and is contained in SECNAV Instruction 3900.-36. Navy experience in reliability programs plans has been incorporated in the new MIL–STD 785A, and the next revision to the aforementioned SECNAV instruction will incorporate the provisions of the new standard for relibility program plans.

Within the Army, reliability programs in accordance with provisions of MIL–STD 785 are required in all contract definition, development and production contracts. This policy is established in Army Regulation 705–50, "Army Materiel Reliability and Maintainability," and is administered by all Army materiel development agencies. No change in this policy is anticipated as a result of MIL–STD–785A superseding MIL–STD–785.

Industry's Role

Industry must gear its management operations in order to comply with the guidance contained in MIL–STD–785A. Care must be exercised in the preparation of the reliability program plan to assure that the plan contains all information to make it responsive. Failure to do so could result in the rejection of a contractor's response to a Request for Proposal.

Contractors who have need for pertinent documents, published by the Military Services, should submit their request through their cognizant DOD contracting agency. MIL–STD–785A can be obtained from the Naval Publications and Forms Center (formerly Naval Supply Depot), 5801 Tabor Ave., Philadelphia, Pa. 19120.

Army Expands R&D Role of Corps of Engineers

Research and development authority and responsibilities of the U.S. Army Corps of Engineers have been expanded and stated more precisely by a new Army Chief of Staff Memorandum.

Under the general staff supervision of the Chief of Research and Development, the Chief of Engineers is charged by the Chief of Staff Memorandum with the following missions:

• Accomplishing research, development, test and evaluation (RDT&E) projects, including basic and applied research required for the engineer mission as assigned, and providing research and development support to the Army, Air Force, National Aeronautics and Space Administration, and other government agencies as required.

• Establishing requirements and performing research and development necessary to provide new construction design criteria, construction techniques, construction material, and facilities maintenance for the Army, Air Force, and other government agencies as required.

• Technical supervision of research and development of engineer techniques and equipment required for combat and combat service support.

The memorandum also prescribes all other aspects of the mission of the Corps of Engineers. Included are the Civil Works Program (now funded at about $1.3 billion annually), all military construction, the Army Installation Master Planning Program, Army Real Estate Services, support to the Assistant Chief of Staff for Intelligence pertaining to mapping and geodetic activities, and responsibilities under the supervision of the Assistant Chief of Staff for Force Development, Deputy Chief of Staff for Military Operations, and Deputy Chief of Staff for Personnel.

Defense Management Challenges—Deputy Secretary Packard Comments

Address by Hon. David Packard, Dep. Secretary of Defense, before the Aerospace Industries Association, Williamsburg, Va., May 22, 1969.

I am pleased to be here this evening. I have been at the Pentagon long enough now to learn about some of the problems—at least I have learned that there are some problems.

The Defense Department presents one of the most demanding management challenges in the world. Continued improvement in this management will be one of the primary objectives of this Administration.

We can identify three different types of problems facing DOD. The first problem is to determine the tasks that are to be performed by DOD. The second problem is to determine the forces that are required to accomplish these tasks. The third is to procure and operate those forces in the most efficient manner.

Determining DOD Tasks

The first of these problems, defining DOD tasks, is the subject of an extensive study for the National Security Council.

There are two questions of great importance involved here:

• Do we have the military force structure adequate to support U.S. commitments around the world?

• What military budget level will the people of the United States support over the next few years?

Both of these questions depend on the turn of many events, both international and domestic.

We in the Defense Department have been working on this problem over the past few months. We touched on it in our budgetary reviews. We are participating in the inter-agency study for the National Security Council (NSC) which will permit NSC to make a decision on the military tasks that must be performed to support U.S. interests in the world. This study must recognize the cost of various tasks that might be performed, and I believe must also recognize that this country's post-Vietnam military budget must withstand the most searching and critical analysis.

This does not trouble me too much because I am sure we can get more defense for our dollar.

And we are working on this problem within the DOD with the hope that we can develop better procedures on which to build our budgets for the future.

This work has resulted in better communication between the Services and the Office of the Secretary of Defense, though I would hasten to add that conflict has not been eliminated—if it ever will be.

A major factor will, of course, be the level of the force structure. Barring another international involvement by the United States somewhere else in the world, the force structure can come down after Vietnam. These studies by the National Security Council will be the major influence in determining the post-Vietnam force level.

The studies will determine the number of men and women we will have in uniform, and something about what kinds of military situations we should be prepared to handle.

Determination of Force Structure

The second major problem faced by DOD is the determination of forces necessary to meet the national objectives.

This problem is not new, as many of you know. Secretary Forrestal had the problem back in 1948. He suggested a two-stage approach.

The first stage was to have the Joint Chiefs prepare their force structure plan—what they believed to be necessary to properly carry out their military missions.

Honorable David Packard

The second stage was to cycle this plan back through with budgetary constraints and achieve an agreed upon plan for which an acceptable budget could be prepared. This would have been a logical approach—more rational than just giving each Service a budget limit and leaving the details for the Services to work out.

Apparently little progress was made toward achieving agreed upon force levels and force structures over the next few years.

Mr. McNamara moved in with a new approach which seemed to have great hope. The plan in simple terms was to select the forces for the various military missions by applying systems analysis and cost effectiveness principles.

We believe that the point of departure in determining force structure must be the defense tasks defined by the National Security Council. These tasks then provide the basis for force development. In this development, we are encouraging the Services to apply system analysis and cost effective procedures themselves. And we are encouraging our people in the Office of the Secretary of Defense to realize that all problems are not solved with analytical procedures alone.

We expect this approach to result in considerable progress toward a rational selection and evaluation of military force levels and weapon systems.

Let us take a few minutes to review where I believe we will be going in some of the important areas which affect you people here tonight.

As a first example, the multiple independent reentry vehicle (MIRV) program raises two issues. One is assuring reliability before production and deployment. The other has to do with arms limitation talks.

We believe we should look very closely at the probable need for a replacement for the B-52 fleet in the next few years. Work is now underway to define the program, and we expect to move ahead in an orderly way.

The Safeguard program, which I am confident Congress will approve, will be for the two sites at Malmstrom and Grand Forks. It will require nearly four years to build and install these two systems, and we have scheduled over a year of testing and system shake-down.

Further expansion or contraction of the system will depend on decisions in the future related to how the Russians and the Chinese move on their strategic forces.

The level and character of our tactical air program will continue to be in a period of uncertainty. The level will be influenced primarily by such decisions as the National Security Council makes on U.S. involvement, world-wide. The character will be determined by further discussions relating to land-based versus sea-based forces. It will be influenced by further discussions relating to air superiority, interdiction and close support. I do not expect all parties to come to a happy agreement on these matters, but I predict they will be influenced heavily by budgetary restraints.

There is no doubt that shipbuilding will be a major program over the next five years, but I do not consider that the level of attack carriers, antisubmarine warfare carriers, nor the related equipment is yet determined.

There are many other areas which will be under close scrutiny. As a result, I believe it is safe to say the whole military hardware field is likely to be fraught with more difficulty over the next few years.

Management of Development and Production

The third problem in the management of DOD is to procure and operate defense resources in the most efficient manner possible. This brings me to some observations about major weapon systems. I have reached the firm conclusion that we are designing and building weapons that are too complex and, therefore, too costly. We further compound the problem by trying to produce hardware before it is fully developed.

This means that we are going to take a very hard look at whether we need all this gadgetry when we go into a new development. A computerized fire control may increase the accuracy of tank gunnery, but so far it does not give evidence of increasing the reliability of gunnery. A tank with its gun out of order is no tank at all.

There will, of course, be cases where a complex device can be very important. There is considerable evidence that many—in fact, I can almost include most complex weapons—are put into production before they are fully developed. We probably cannot go to a "prototype for everything" route, but we can do a much better job in relating production and development.

What does this all mean in specific things that might be done? We do not, at this time, have plans worked out as to exactly how to attack these problems. There are some things I can say however.

We expect to have all future contracts for weapon systems include realistic achievement milestones which must be met before production is started. We need and will welcome your cooperation in developing workable procedures toward that end.

The Services will have to accept production schedules which are not tied to specific dates, but can expect rigid time schedules once production is authorized.

A related question is costing. I know you have been wrestling with this problem for some time, and I have only one thing to say on this subject now. You have to eliminate this business of buying in. Neither the Defense Department nor the Congress will continue to tolerate large cost overruns which relate to unrealistic pricing at the time of award, or to inadequate management of the job during the contract.

In simple terms, you will find it much more difficult for us to consider upward price revisions—and you should plan your affairs accordingly.

The Defense Department needs the help and support of the members of this audience. We will, as I have said, examine our requirements for new equipment more carefully. We are certain to have the continuing constraint of budgetary pressures on these requirements. We simply have to find ways to buy more defense for our taxpayer's dollar. We need your help. We need your help in building equipment with higher standards of reliability. We need your help in improving the development and production efficiency on military hardware. We need significant improvement in the accuracy of cost estimates, and in achieving better performance against cost targets. These are goals which are well within the capability of the aerospace industry. I hope you will agree with me that we should not and cannot settle for less.

Fleet Ships To Use New Fuel

The Navy is shifting to a new fuel to replace the Navy Special Fuel Oil (NSFO) for ship propulsion.

An all-distillate marine diesel type of fuel will take the place of NSFO on a time-phased basis, allowing the industry to adjust to the new requirements. The Navy could start using the new fuel as early as March 1970, reaching a peak of an estimated 46 million barrels a year by February 1972.

Although the new fuel will cost about $48 million more per year, operating costs will be reduced due to decreased maintenance. Total savings are expected to be millions of dollars per year when the new fuel is fully in use.

The use of the all-distillate fuel will greatly reduce shipboard boiler repairs and maintenance, resulting in improved ship readiness.

Before the Fleet can use the new fuel, however, shipboard fuel pumps and related equipment will have to be modified or replaced to handle the lower density of the fuel.

The interim specification for the new fuel, MIL–F24374 (Ships), is available from Navy Publication and Forms Center, NPSC–103, 5801 Tabor Ave., Philadelphia, Pa. 19120.

Secretary of Defense Laird Urges Continued Cost Reduction Effort

[Editor's note: The following letter dated May 16, 1969, forwarded by Secretary of Defense Melvin R. Laird to the active participants in the Defense Contractor Cost Reduction Program, is reprinted in the Bulletin *as a matter of interest to our readers.]*

"In my seventeen years of Defense service here in Washington, there has never been a period when the socio-economic need of our Nation focused such critical attention on Defense expenditures. That attention is deserved, for no department of our Government faces a more impressive management challenge.

"These times impose a special responsibility on everyone entrusted with the disposition of Defense funds —Government employees and Defense contractors alike. It is an unusual responsibility because the dimensions of the job to be done demand more from our talents than reasonable prudence and average success.

"We are continuously being asked to manage better. We are being asked to speed up innovation— to take new, major steps in our quest for more efficient, less costly ways to keep our defenses unassailable.

"This Department is moving quickly to meet the test. Since January, we have—

- established a Joint Logistic Review Board, consisting of high-ranking military officials, to review world-wide logistics support to combat forces during the Vietnam era, to identify strengths and weaknesses and make appropriate recommendations for improvement.
- instituted a Logistics Performance Measurement and Evaluation System for setting goals, measuring progress, and analyzing results in key logistics programs, functions and activities.
- applied new emphasis to our in-house Cost Reduction Program, from which we should realize over $1 billion in audited in-house savings this current fiscal year.
- set the groundwork for convening a Blue Ribbon Panel to review our entire Defense Department activities.

"Actions like these will bring us part way toward President Nixon's objectives of making "the most effective use . . . of all the country's resources in achieving the Nation's goals" and accomplishing "Governmental functions . . . with the least possible waste." I say "part way" because Defense cannot go it alone. We must rely heavily on industry's integrity and ingenuity to help us meet these objectives.

"I know that your firm—as one of the participants in the Defense Contractor Cost Reduction Program—appreciates the gravity of this responsibility and the immensity of the challenge. I am informed that you and your fellow contributors to this Program—through better manufacturing processes, value engineering, closer pricing of subcontracts, and other techniques of progressive management—have recorded cost benefits to Defense exceeding half-a-billion dollars in the 1st Half of FY 1969. To me, that kind of visible achievement speaks louder than repeated assurances of shared concern.

"It is my sincere belief that this Department and industry—working together—can give our Government the best value it has ever received in the Defense materiel and equipment it needs and can strengthen our procurement practices far beyond the norm of adequacy.

"I believe these are realistic expectations—and I know that I can count on your firm and on you personally to do your best to meet them. Further, I would welcome any proposals for improvement that you might have."

/signed/ Melvin R. Laird

Army Investigating Liquid Natural Gas as Turbine Fuel

The use of liquified natural gas as a replacement for general purpose (JP) fuel for helicopter gas turbines is being considered by the U.S. Army. The Army's Combat Developments Command (CDC), Fort Belvoir, Va., is seeking a cryogenic fuel in an effort to increase aircraft performance, safety and maintenance standards.

The CDC's Combat Service Support Group, Fort Lee, Va., has been looking at methane as the possible replacement. Tests have shown that methane permits higher internal combustion temperatures with resulting higher horsepower outputs. At 3,000 degrees F. methane yields 305 horsepower per pound of fuel per second, while JP fuel is temperature limited to 2,200 degrees and 200 horsepower. Even higher combustion temperatures are possible with methane, with resulting increased horsepower ratings.

To counteract the increased temperatures, methane's cryogenic properties would allow it to be channeled through the aircraft to cool working parts. Used to cool the turbines exhaust, this would, in turn, decrease the aircraft's infrared "signature."

CDC sees other advantages to such cryogenic fuels. Methane's low vaporization temperature would eliminate fuel-drenched accident scenes. It is non-toxic, inexpensive and as plentiful as petroleum. A "clean" fuel, methane produces little carbon and sulpher to clog engine parts and pollute the air.

Present shipping and storing facilities for JP fuel would have to be changed for methane, and a double-walled, lightweight fuel tank for aircraft would be required before any changeover.

ABOUT PEOPLE

DEPARTMENT OF DEFENSE

Dennis James Doolin has been sworn in as Dep. Asst. Secretary of Defense (International Security Affairs) for East Asia and Pacific Affairs. He succeeds **Richard A. Steadman**, who has entered private business.

Dr. Roland F. Herbst, formerly of the University of California's Lawrence Radiation Laboratory, is now Dep. Dir. (Strategic and Space Systems), Office of Dir. of Defense Research and Engineering. He succeeds **Dr. Lloyd R. Wilson**, who has entered private business.

Brig. Gen. Arthur E. Exon, USAF, Commander, Defense Contract Administration Services Region, Los Angeles, Calif., has retired.

The Defense Contracts Administration Services District, Indianapolis, at Fort Benjamin Harrison, Ind., has a new Commander, **Col. Robert W. Allen, USA.**

Col. James B. Myers, USAF, has been named Chief, Special Projects Division, Defense Atomic Support Agency, Arlington, Va.

Col. John W. Oliver, USAF, is the new Chief, Satellite Communications Field Office, Defense Communications Agency, Fort Monmouth, N.J.

Cmdr. Calvin R. Anweiler, SC, USN, has been assigned as Commander, Twin Cities District, St. Paul, Minn., of the Defense Contract Administration Region, St. Louis, Mo.

DEPARTMENT OF THE ARMY

Thaddeus R. Beal has been sworn in as Under Secretary of the Army.

Maj. Gen. Robert E. Coffin has left his position as Dep. Chief of Research and Development. **Brig. Gen. Kenneth F. Dawalt**, former Dep. Chief Research and Development for International Programs, is acting Dep. Chief.

Maj Gen. William C. Gribble has assumed command of the Army Engineer Center and Fort Belvoir, Va.

Maj Gen. Lee B. Jones has been named Chief of Staff, Army Materiel Command, Washington, D.C.

The Army Corps of Engineers, Washington, D.C., has announced the following assignments: **Maj. Gen. Frederick J. Clarke**, Dep. Chief of Engineers, will become Chief of Engineers on August 1. **Maj. Gen. Carrol H. Dunn** will succeed Maj. Gen. Clarke as Dep. Chief. **Maj. Gen. Richard H. Free** will become Division Engineer, South Atlantic Division, Atlanta, Ga., and **Brig. Gen. Daniel A. Raymond** will become Dir. of Military Construction, Office of the Chief of Engineers on August 1. **Brig. Gen. William W. Watkin Jr.** is now Division Engineer, North Central Division, Chicago, Ill.

Col. Frank B. Case has been named Dir. of Plans, Military Traffic Management and Terminal Service, Bailey's Crossroads, Va.

Col. Richard A. Hiscox has been appointed Asst. Dir. of the Budget (Operations), Office of the Army Comptroller, replacing **Brig. Gen. Lewis E. Maness.**

The Army Munitions Command, Dover, N.J., has a new Dep. Commander, **Col. Peter G. Olenchuk.**

DEPARTMENT OF THE NAVY

RAdm. Lawrence G. Bernard is the new Dir., Shore Installations Division, Office of the Chief of Naval Operations, replacing **RAdm. Frederick E. Janney.** RAdm. Janney will become Dep. Chief of Staff, Military Assistance Logistics and Administration, Joint Staff of the Commander in Chief, Pacific.

RAdm. Ira F. Haddock, SC, has been named Commander, Naval Supply Center, Norfolk, Va.

RAdm. Howard S. Moore has been chosen as the new Commander, Pacific Missile Range, Point Mugu, Calif.

Capt. Kenneth W. Cramp will be the new Dir., Naval Electronics Systems Command, Western Division, at San Francisco Naval Shipyard, Vallejo, Calif.

Capt. Bernard W. Frese has been selected to relieve **Capt. Leslie R. Olsen** as Commander, Naval Ordnance Station, Indian Head, Md. Capt. Leslie is retiring.

Capt. Clarence T. Froscher has been named Commander, Naval Air Engineering Center, Philadelphia, Pa.

Capt. James L.F. Hennessy, SC, has been assigned as Dep. Commander/Chief of Staff, Western Area, Military Traffic Management and Terminal Service, Oakland, Calif.

The new West Coast Representative of the San Diego Technical Office, Deep Submergence Systems Project, is **Capt. Walter F. Mazzone.**

Capt. Blake W. Van Leer is the new Commander, Chesapeake Division, Naval Facilities Engineering Command, Washington, D.C.

DEPARTMENT OF THE AIR FORCE

Spencer J. Schedler has been nominated as the replacement for **Thomas H. Neilson** as Asst. Secretary of the Air Force (Financial Management).

Brig. Gen. Richard M. Hoban has been named Vice Commander, San Antonio Air Materiel Area, (AFLC), Kelly AFB, Tex.

The Sacramento Air Materiel Area, (AFLC), McClellan AFB, Calif., has a new Vice Commander, **Brig. Gen. Edwin L. Little.**

Brig. Gen. Gustav E. Lundquist, Commander, Arnold Engineering Development Center, (AFSC), Arnold AFS, Tenn., will retire at the end of July.

Col. Brian S. Gunderson, (brig. gen. selectee), has been assigned **Chief of Staff, U.S. Air Force in Europe.**

Col. Charles C. Pattillo, (brig. gen. selectee), has been named Vice Commander, Oklahoma City Air Materiel Area, (AFLC), Tinker AFB, Okla.

The Air Force Systems Command has chosen **Col. Milton R. Buls** as Dir., Foreign Technology, Aeronautical Systems Division, Wright-Patterson AFB, Ohio.

Col. Lawrence A. Fowler will become Dir., Procurement and Production, Manned Orbiting Laboratory, Space and Missile Systems Organization, (AFSC), Los Angeles, Calif.

Col. Ralph A. Johnson has been named to succeed **Brig. Gen. James A. Bailey** as Vice Commander, Warner

Robins Air Materiel Area, (AFLC), Robins AFB, Ga.

Col. Rio G. Lucas is the new Asst. for Engineering/Construction, Office of the Asst. Secretary of the Air Force (Installation and Logistics).

Air Force Systems Command has named **Col. Ernest F. Moore** as its Dir. Civil Engineering, Arnold Engineering Development Center, Arnold AFS, Tenn.

Col. Clifford E. Smith has been assigned as Chief, Requirements Div., Air Force Systems Command headquarters, Andrews AFB, Md.

Col. Elbert M. Stringer is the new Dir., C–141/C–130 Systems Program Office, Aeronautical Systems Div., (AFSC), Wright-Patterson AFB, Ohio. He will also manage the B–57G and C–9 programs.

Integrated Logistics

(Continued from page 33)

Today, and for the future, as General Hamilton was so keenly aware, it is an absolute necessity that there be an understanding of the requirements for combat and the requirements for support. Further, it is necessary that the requirements for both be balanced and comprehended for it is at the end of the line, at the sharp point of the bayonet, where the warfare and support concepts focus. Because our weapons, technology and methodology are today so terribly complex, they demand the application of engineering principles to shape the total logistic system and configure it to satisfy its ultimate objective—WARFARE.

Army Closing Five Nike Hercules Sites

The Department of the Army has announced the closing of five Nike Hercules firing sites in four states in the continental United States. It is expected that the closing will save the Army $3.6 million in FY 1970 and in each succeeding year.

The sites to be closed are Milwaukee, Wis., Detroit and Carlton, Mich., Warrington, Pa., and Felicity, Ohio. The sites at Milwaukee and Detroit are manned by active Army units. All units will be converted to other unit types.

Military Activities Realigned To Meet Budget Cuts

Secretary of Defense Melvin R. Laird has announced changes aimed at budget reductions affecting 36 military installations and activities in the United States. Among the most significant planned are the realignment of the North American Air Defense Command (NORAD), reorientation of the Army and Navy's research and development establishments, and the consolidation of three Defense Supply Agency's (DSA) Subsistence Regional Headquarters.

The realignment of NORAD's ground environment and command control structure is intended to modernize the air defense system. Key changes in the realignment include phasing out of the 4th Air Force Aerospace Defense Command and its combat center, Hamilton AFB, Calif., and the 36th NORAD Division Headquarters and Direction Center, Adair AFS, Oregon.

In addition, one aircraft control and warning station, five defense early warning stations and six radar squadrons will be closed by September 1969 and two additional aircraft control and warning stations and two radar stations will be closed by December 1969. Three of the sites will be taken over by the Federal Aviation Agency.

The Army and Navy research and development reorientation will affect the Army's Frankford Arsenal, Philadelphia, Pa., which will be relocated. The limited production capacity of the arsenal will be retained. Three Naval laboratories will be affected, including the Naval Weapons Center Corona Laboratories, Corona, Calif., which will be consolidated with the Naval Weapons Center, China Lake, Calif., with the exception of the Fleet Missile Systems Analysis and Evaluation Group which will remain at the Corona facility. The Naval Radiological Defense Laboratory, San Francisco, Calif., will be disestablished and functions will be transferred to other Naval facilities. The activities of the Naval Applied Science Laboratory, Brooklyn, N.Y., will be reduced to only the current navigational efforts by June 1970.

DSA Subsistence Regional Headquarters changes include consolidation of the Seattle, Wash., and Los Angeles, Calif., headquarters with the Alameda, Calif., facility, and consolidation of the Kansas City headquarters with those in New Orleans, La., and Chicago, Ill.

Army Terminates Cheyenne Production

The Department of the Army has terminated the production phase of the AH-56A Cheyenne armed helicopter program. The reason given was for default of the contractor, Lockheed Aircraft Corp.

Simultaneously it was announced that Lockheed may be issued a "cure notice" on the research and development contract for the Cheyenne, notifying the company of deficiencies. Army officials are hopeful, however, that a satisfactory program to permit continuation of development can be devised.

The termination affected only the production phase of the Cheyenne program.

DFSC To Use New Type Contracting for Buying Coal

The Defense Fuel Supply Center is planning to change the types of contracts it uses for purchasing coal for military installations. The change will be from the current firm quantity contracts to requirement contracts, which are used where required quantities cannot be accurately forecast.

The new contracts will include an estimated yearly total quantity needed by an installation, but will also give a maximum tonnage the supplier may be called on to furnish. Greater flexibility is expected by allowing each installation's ordering officer to contact the contractor for delivery schedules, benefiting the supplier through more accurate planning. Large quantity deliveries could be planned to take advantage of possible volume freight rates, with resulting lower costs.

The center, a field activity of the Defense Supply Agency, located in Alexandria, Va., annually buys $22 million worth of coal. The changeover will be made on a phased basis. No other change will be made in current purchasing methods or in contracts for civil agency installations.

DEFENSE PROCUREMENT

Contracts of $1,000,000 and over awarded during the month of May, 1969.

DEFENSE SUPPLY AGENCY

1—**Sinclair Oil Corp.**, New York, N.Y. $1,378,117. Various quantities of fuel oil and gasoline. Defense Fuel Supply Center, Alexandria, Va. DSA 600-69-D-1678.

2—**Aluminum Company of America**, Pittsburgh, Pa. $12,853,984. 40,806,300 pounds of aluminum powder. Defense General Supply Center, Richmond, Va. DSA 400-69-C-5534.

—**Sinclair Oil Co.**, New York, N.Y. $2,797,777. Various quantities of fuel oil and gasoline. Defense Fuel Supply Center, Alexandria, Va. DSA 600-69-D-1506.

—**Gulf Oil Corp.**, Houston, Tex. $2,547,229. Various quantities of fuel oil and gasoline. Defense Fuel Supply Center, Alexandria, Va. DSA 600-69-D-1492.

—**Alcan Metal Powders, Inc.**, Elizabeth, N.J. $1,141,312. 3,566,600 pounds of aluminum powder. Defense General Supply Center, Richmond, Va. DSA 400-69-C-5533.

6—**General Foods Corp.**, White Plains, N.Y. $2,029,268. 3,520,000 two-pound containers of instant rice. Dover, Del. Defense Personnel Support Center, Philadelphia, Pa. DSA 130-69-C-M126.

9—**Gulf Oil Corp.**, New York, N.Y. $2,692,800. 30,000,000 gallons of JP-4 jet fuel. Puerto Rico. Defense Fuel Supply Center, Alexandria, Va. DSA 600-69-D-1839.

12—**Gulf Oil Corp.**, Houston, Tex. $3,781,690. 10,700 gallons premium gasoline, 3,683,040 gallons regular gasoline, 4,466,100 gallons diesel fuel, 212,100 gallons kerosene and 25,153,100 gallons fuel oil. Defense Fuel Supply Center, Alexandria, Va. DSA 600-69-D-1248.

14—**Mobile Oil Corp.**, New York N.Y. $1,337,500. 250,000 barrels of Grade DF-A diesel fuel for the Army. Defense Fuel Supply Center, Alexandria, Va. DSA 600-69-D-0570 POO1.

—**Cherubineo Petti and Co., Inc.**, Atlantic City, N.J. $1,408,500. 75,000 men's wool serge coats. Defense Personnel Support Center, Philadelphia, Pa. DSA 100-69-C-2319.

15—**Towmotor Corp.**, Cleveland, Ohio. $1,391,175. 229 gasoline-powered forklift trucks. Defense General Supply Center, Richmond, Va. DSA 400-69-C-5747.

—**Alpha Industries, Inc.**, Knoxville, Tenn. $1,379,000. 250,000 men's cotton-nylon coats with hoods. Defense Personnel Support Center, Philadelphia, Pa. DSA 100-69-C-2317.

16—**Pettibone Mulliken Corp.**, Washington, D.C. $1,755,988. 226 electric forklift trucks. Defense General Supply Center, Richmond, Va. DSA 400-69-C-6073.

—**Damascus Hosiery Mills, Inc.**, Damascus, Va. $1,172,299. 2,000,000 pairs of men's socks. Defense Personnel Support Center, Philadelphia, Pa. DSA 100-69-C-2427.

19—**Putnam Mills Corp.**, New York, N.Y. $2,844,940. 3,673,000 yards of wind resistant poplin. Marion, N.C., Whitmore, S.C., Great Falls, S.C., and Columbus, Ga. Defense Personnel Support Center, Philadelphia, Pa. DSA 100-69-C-2425.

CONTRACT LEGEND

Contract information is listed in the following sequence: Date—Company — Value — Material or Work to be Performed—Location of Work Performed (if other than company plant) — Contracting Agency—Contract Number.

—**American Oil Co.**, Chicago, Ill. $2,704,576. Fuel oil and gasoline. Defense Fuel Supply Center, Alexandria, Va. DSA 600-69-D-1510.

—**Burlington Industries, Inc.**, New York, N.Y. $2,302,200. 3,00,000 yards of wind resistant poplin. Mooresville, N.C., Cheraw, S.C., and Cramerton, N.C. Defense Personnel Support Center, Philadelphia, Pa. DSA 100-69-C-2426.

—**Valley Metallurgical Processing Co.**, Essex, Conn. $2,111,740. 3,105,500 pounds of magnesium powder. Stockton, Calif. Defense General Supply Center, Richmond, Va. DSA 400-69-C-5728.

—**Hart Metals, Inc.**, Tamaqua, Pa. $1,159,396. 1,698,750 pounds of magnesium powder. Defense General Supply Center, Richmond, Va. DSA 400-69-C-5729.

20—**American Oil Co.**, Chicago, Ill. $1,765,248. Various quantities of fuel oil. Defense Fuel Supply Center, Alexandria, Va. DSA 600-69-D-1447.

22—**Gibralter Fabrics, Inc.**, Brooklyn, N.Y. $1,015,243. 166,350 liners for men's field coats. Brooklyn, and Bridgeton, N.J. Defense Personnel Support Center, Philadelphia, Pa. DSA 100-69-C-2489.

23—**Bibb Manufacturing Co.**, Macon, Ga. $3,498,550. 760,730 linear yards of 45-inch wide nylon twill cloth. Salisbury, N.C., Macon, Columbus and Percale, Ga. Defense Personnel Support Center. Philadelphia, Pa. DSA 100-69-C-2500.

—**Phipps Products Corp.**, Boston, Mass. $1,675,007. Petrochemicals. Defense Fuel Supply Center, Alexandria, Va. DSA 640-69-D-2151.

27—**J.P. Stevens and Co., Inc.**, New York, N.Y. $4,727,406. 1,286,168 yards of wool serge cloth. Greer and Wallace, S.C. Defense Personnel Support Center, Philadelphia, Pa. DSA 100-69-C-2507.

28—The Defense Fuel Supply Center, Alexandria, Va., has awarded the following 53 contracts for JP-4 and JP-5 fuel:

Fletcher Oil & Refining Co., Carson, Calif. $1,607,236. 12,500,000 gallons. DSA 600-69-D-1972.

Golden Eagle Refining Co., Inc., Los Angeles, Calif. $5,139,854. 39,900,000 gallons. DSA 600-69-D-1973.

Humble Oil & Refining Co., Houston, Tex. $12,717,187. 116,472,000 gallons. DSA 600-69-D-1975.

Kern County Refinery, Inc., Los Angeles, Calif. $1,205,069. 8,830,000 gallons. DSA 600-69-D-1979.

Mobil Oil Corp., New York, N.Y. $16,001,712. 152,092,250 gallons. DSA 600-69-D-1981.

Powerline Oil Co., Santa Fe Springs, Calif. $3,161,408. 25,000,000 gallons. DSA 600-69-D-1983.

Shell Oil Co., New York, N.Y. $3,898,800. 38,000,000 gallons. DSA 600-69-D-1984.

U.S. Oil & Refining Co., Tacoma, Wash. $1,193,061. 9,056,250 gallons. DSA 600-69-D-1986.

American Oil Co., Chicago, Ill. $8,552,559. 81,527,730 gallons. DSA 600-69-D-1993.

Adobe Refining Co., La Blanca, Tex. $1,781,329. 15,000,000 gallons. DSA 600-69-D-1991.

Alabama Refining Co., Inc., Theodore, Ala. $7,392,500. 70,000,000 gallons. DSA 600-69-D-1992.

American Petrofina Co. of Texas, Dallas Tex. $3,642,037. 34,975,000 gallons. DSA 600-69-D-1994.

Bell Oil & Gas Co., Bartlesville, Okla. $4,505,060. 44,849,000 gallons DSA 600-69-D-2001.

Cardinal Transports, Inc., San Antonio, Tex. $1,267,800. 12,000,000 gallons. DSA 600-69-D-2003.

Cities Service Oil Co., New York, N.Y. $1,133,285. 11,340,000 gallons. DSA 600-69-D-2006.

Coastal States Petrochemical Co., Houston, Tex. $19,017,842. 182,516,000 gallons. DSA 600-69-D-2007.

Continental Oil Co., Houston, Tex. $11,152,588. 108,628,000 gallons. DSA 600-69-D-2009.

Crystal Flash Petroleum Corp., Indianapolis, Ind. $1,467,675. 12,510,000 gallons. DSA 600-69-D-2010.

Delta Refining Co., Memphis, Tenn. $4,435,816. 41,900,000 gallons. DSA 600-69-D-2011.

Diamond Shamrock Corp., Amarillo, Tex. 3,555,090. 32,062,000 gallons. DSA 600-69-D-2012.

Edgington Oil Co., Long Beach, Calif. $2,569.636. 20,500,000 gallons. DSA 600-69-D-2014.

Famariss Oil & Refining Co., Hobbs, N.M. $1,160,719. 9,000,000 gallons. DSA 600-69-D-2016.

Atlantic Richfield Co., Philadelphia, Pa. $10,641,750. 105,000,000 gallons. DSA 600-69-D-1998.

Fletcher Oil & Refining Co., Carson, Calif. $2,633,500. 21,000,000 gallons DSA 600-69-D-2017.

Fort Worth Refining Co., Houston, Tex. $5,008,693. 45,000,000 gallons. DSA 600-69-D-2018.

Getty Oil Co., New York, N.Y. $6,449,746. 60,278,000 gallons. DSA 600-69-D-2019.

Golden Eagle Refining Co., Los Angeles, Calif. $6,078,135. 48,300,000 gallons. DSA 600-69-D-2021.

Good Hope Refineries, Inc., Houston, Tex. $4,678,200. 46,000,000 gallons. DSA 600-69-D-2022.

Hess Oil & Chemical Corp., Woodbridge, N.J. $4,439,610. 45,360,000 gallons. DSA 600-69-D-2025.

Humble Oil & Refining Co., Houston, Tex. $38,445,535. 378,000,000 gallons. DSA 600-69-D-2026.

Howell Refining Co., San Antonio, Tex. $3,170,317. 27,500,000 gallons. DSA 600-69-D-2027.

Hunt Oil Co., Dallas, Tex. $1,098,900. 11,000,000 gallons. DSA 600-69-D-2028.

Kern County Refinery, Inc., Los Angeles, Calif. $2,129,175. 16,320,000 gallons. DSA 600-69-D-2032.

Macmillan Ring-Free Oil Co., Los Angeles, Calif. $4,026,580. 32,308,500 gallons. DSA 600-69-D-2038.

Mobil Oil Corp., New York, N.Y. $20,557,255. 183,800,000 gallons. DSA 600-69-D-2039.

Monarch Refining Co., San Antonio, Tex. $1,066,028. 9,000,000 gallons. DSA 600-69-D-2040.

Okmulgee Refining Co., Inc., Okmulgee, Okla. $1,794,753. 18,140,000 gallons. DSA 600-69-D-2042.

Phillips Petroleum Co., Bartlesville, Okla. $9,801,264. 84,980,000 gallons. DSA 699-69-D-2045.

Pride Refining Inc., Abilene, Tex. $2,084,508. 18,000,000 gallons. DSA 600-69-D-2046.

Signal Oil & Gas Co., Houston, Tex. $1,137,950. 11,000,000 gallons. DSA 600-69-D-2048.

Southwestern Oil & Refining Co., Corpus Christi, Tex. $6,306,300. 63,000,000 gallons. DSA 600-69-D-2050.

Southwestern Pallet Co., Abilene, Tex. $1,185,129. 10,132,000 gallons. DSA 600-69-D-2051.

Shell Oil Co., New York, N.Y. $1,510,880. 15,200,000 gallons. DSA 600-69-D-2052.

Sun Oil Co., Philadelphia, Pa. $8,074,560. 74,400,000 gallons. DSA 600-69-D-2054.

Suntide Refining Co., Tulsa, Okla. $2,978,700. 30,000,000 gallons. DSA 600-69-D-2055.

Sun Oil Co., Tulsa, Okla. $2,802,300. 30,000,000 gallons. DSA 600-69-D-2056.

Tesoro Petroleum Corp., San Antonio, Tex. $5,038,670. 41,000,000 gallons. DSA 600-69-D-2057.

Tonkawa Refining Co., Houston, Tex. $2,146,604. 20,000,000 gallons. DSA 600-69-D-2059.

Triangle Refineries, Inc., Houston, Tex. $2,478,090. 21,500,000 gallons DSA 600–69–D–2060.

Union Oil Co., Los Angeles, Calif. $4,-356,374. 35,240,000 gallons. DSA 600–69–D–2061.

Southland Oil Co, Yazoo City, Miss. $1,160,654. 10,500,000 gallons. DSA 600–69–D–2049

Ashland Oil & Refining Co., Ashland, Ky. $5,931,687. 56,440,000 gallons. DSA 600–69–D–1997.

Bayou Refining Co., Inc., Pasadena, Tex. $3,909,225. 37,056,000 gallons. DSA 600–69–D–1999.

—**Servicemaster Industrial Systems Co.**, Downersgrove, Ill. $1,133,334. 143,460 coated nylon twill, wet weather parkas. Cairo, Ill. Defense Personnel Support Center, Philadelphia, Pa. DSA 100–69–C–2560.

—**J. P. Stevens & Co., Inc.**, New York, N.Y. $3,556,600. 984,000 linear yards of wool serge cloth. Green and Wallace, S.C. Defense Jersonnel Support Center, Philadelphia, Pa. DSA 100–69–C–2508.

—**Brownwood Mfg. Co.**, Dallas, Tex. $1,159,-269. 448,200 pairs of men's wind resistant, cotton poplin trousers. Early and Brownwood, Tex. Defense Personnel Support Center, Philadelphia, Pa. DSA 100–69–C–2538.

29—**Burlington, Industries, Inc.**, New York, N.Y. $3,298,677. 1,679,296 yards of polyester and wool tropical cloth. Raeford, N.C., Halifax and Clarksville, Va. Defense Personnel Support Center, Philadelphia, Pa. DSA 100–69–C–2535.

—**J. P. Stevens & Co., Inc.**, New York, N.Y. $1,502,424. 1,104,000 yards of oxford cloth. Whitmire, S.C., and Westerly, R.I. Defense Personnel Support Center, Philadelphia, Pa. DSA 100–69–C–2561.

—**Hess Oil & Chemical Corp.**, Woodbridge, N.J. $2,890,220. 26,050,000 gallons of JP-5 jet fuel. Port Reading, N.J. Defense Fuel Supply Center, Alexandria, Va. DSA 600–69–D–1978.

—**Delta Petroleum Co., Inc.**, New Orleans, La. $1,316,169. 2,568,661 gallons of lubricating oil. Defense Fuel Supply Center, Alexandria, Va. DSA 600–69–D–2106.

—**Sun Oil Co.**, Philadelphia, Pa. $1,116,887. 9,669,000 gallons JP-5 jet fuel. Defense Fuel Supply Center, Alexandria, Va. DSA 600–69–D–1985.

DEPARTMENT OF THE ARMY

1—**Jervis B. Webb Co., of Calif.**, Washington, D.C. $1,322,663. Furnish and install a material handling system at Tooele Army Depot to automate receiving and shipment of general supplies. Detroit, Mich., and South Gate, Calif. San Francisco Procurement Agency, Oakland, Calif. DA–AG05–69–C–0727.

—**KDI Precision Products, Inc.**, Cincinnati, Ohio. $1,139,040 (contract modification). 2.75-inch rocket fuze safety and arming devices. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA–AA09–69–C–0593.

—**Acushnet Co.**, New Bedford, Mass. $1,008,-934. Navy gas masks. Edgewood Arsenal, Md. DA–AA15–69–C–0593.

2—**American Machine and Foundry Co.**, New York, N.Y. $4,056,000 (contract modification). Metal parts for 750-pound general purpose bombs. Garden City, N.Y. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA–AA09–69–C–0035.

—**Jackes Evans Manufacturing Co.**, St. Louis, Mo. $2,668,000. M13 links for 7.62 mm cartridges. Frankford Arsenal, Philadelphia, Pa. DA–AA25–69–C–0522.

—**Sperry Rand Corp.**, Washington, D.C. $2,-500,000. Classified electronic equipment. St. Paul, Minn. Army Electronics Command, Fort Monmouth, N.J.

—**Union Carbide Corp.**, New York, N.Y. $1,990,710 (contract modification). Power supplies for M514 fuzes for artillery projectiles. Bennington, Vt. Harry Diamond Laboratory, Washington, D.C. DA–AG39–69–C–0073.

—**AVCO Corp.**, Stratford, Conn. $1,506,130. Turbine nozzles for T53 gas turbine engines for UH-1 helicopters. Army Aviation Materiel Command, St. Louis, Mo. AF–41–608–69–A–2421.

—**AVCO Corp.**, Stratford, Conn. $1,277,500. Fuel controls and inlet guide units for T54 turbine engines for CH-47 helicopters. Army Aviation Materiel Command, St. Louis, Mo. AF–41–608–69–A–2421.

5—**General Electric Co.**, Bethesda, Md. $1,-338,673. Purchase of previously installed and rented GE 635 computer system at Griffiss AFB, N.Y. Army Electronics Command, Philadelphia, Pa. GS–OOOS–76171.

—**Sylvania Electronic Systems**, Mountain View, Calif. 1,105,200. Telephone analyzer sets. Mountain View, Calif., and Santa Cruz, Calif. San Francisco Procurement Agency, Oakland, Calif. DA–AB05–69–C–0712.

6—**M. Morrin & Sons Co., Inc.**, Odgen, Utah. $1,249,900. Construction of an ammunition maintenance facility at Tooele Army Depot, Tooele, Utah. Army Engineer District, Sacramento, Calif. DA–CA05–69–C–0095.

—**Hallicrafters Co.**, Rolling Meadows, Ill. $1,000,000. AN/ALQ80 radar jammers and test fixtures. Army Electronics Command, Fort Monmouth, N.J. DA–AB07–69–C–00100.

7—**Bell Aerospace Corp.**, Fort Worth, Tex. $1,993,700. Rotor modification kits for AH-1 helicopters. Hurst, Tex. Army Aviation Systems Command, St. Louis, Mo. DA–AJ01–69–A–0314.

—**Olin Mathieson Chemical Corp.**, East Alton, Ill. $1,050,873. .45 caliber cartridges. Frankford Arsenal, Philadelphia, Pa. DA–AA25–69–C–0537.

8—**Standard Container Co.**, Montclair, N.J. $4,515,000. Metal ammunition boxes. Homerville, Ga. Frankford Arsenal, Philadelphia, Pa. DA–AA25–69–C–0185.

9—**R.G. LeTourneau, Inc.**, Long View, Tex. $5,980,800 (contract modification). Metal parts for 750-pound bombs. Longview, Lone Star, Tex., and other locations. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA–AA09–69–C–0044.

—**Flinchbaugh Products, Inc.**, Red Lion, Pa. $2,393,373. Warheads, insulation assemblies and motor body bonding assemblies for 105mm projectiles. Picatinny Arsenal, Dover, N.J. DA–AA21–69–C–0619.

—**Bell Aerospace Corp.**, Fort Worth, Tex. $6,664,874. Rotary wings blades for UH–1 helicopter. $1,867,780. UH–1 hanger assemblies. $1,338,430. UH-1 tail rotor hubs. Hurst, Tex. Army Aviation Systems Command, St. Louis, Mo. DA–AJ01–69–A–0314.

12—**MacGregor-Triangle Co.**, Boise, Idaho. $3,-569,651. Relocation of 8.7 miles of road at Libby Dam Project, Mont. Army Engineer District, Seattle, Wash. DA–CW67–69–C–0037.

—**Martin K. Eby Construction Co., Inc.**, Wichita, Kan. $1,226,944. Construction of enlisted men's barracks and medical facility, Fort Leonard Wood, Mo. Army Engineer District, Kansas City, Mo. DA–CA41–69–C–0064.

—**Chrysler Motors Corp.**, Warren, Mich. $1,-202,949. Transmissions, differentials and rear axles for ¾-ton trucks (M37). Army Tank Automotive Command, Warren, Mich. DA–AE07–69–C–3447.

13—**Whittaker Corp.**, Westerville, Ohio. $1,-157,384. Metal parts for 105mm projectiles (M489). Columbus, Ohio. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA–AA09–69–C–0410.

—**Kaiser Aerospace and Electronics Corp.**, Glendale, Calif. 1,032,150. Long lead time items for fabrication, test and assembly of detection devices. Harry Diamond Laboratories, Washington, D.C. DA–AG39–69–C–0049.

—**Kanaar Corp.**, Kingston, Pa. $2,445,885. Shoulder-operated 40mm grenade launchers. Army Weapons Command, Rock Island, Ill. DA–AF03–69–C–0084.

—**Gentex Corp.**, Carbondale, Pa. $1,575,000. 21,000 SPH-4 air crewmen protective helmets. Army Procurement Agency, New York, N.Y. DA–AG25–69–C–0881.

14—**Telex-Midwestern Division**, Tulsa, Okla. $1,500,000. Classified electronic equipment. Army Electronics Command, Fort Monmouth, N.J.

15—**General Motors Corp.**, Cleveland, Ohio. $1,191,494. Engineering design and testing of the XM-70 tank. Army Tank Automotive Command, Warren, Mich. DA–20–113–AMC–08843(T).

16—**King-Hunter, Inc.**, Greensboro, N.C. $1,-654,227. Construction of a two-story addition to a building at Tarheel Army Missile Plant, Burlington, N.C. Army Engineer District, Savannah, Ga. DA–CA21–69–C–0113.

—**Union Carbide Corp.**, New York, N.Y. $1,193,215. BA270/U dry batteries for AN/PRC-6 radio sets. Charlotte, N.C. Procurement Division, Army Electronics Command, Philadelphia, Pa. DA–AB05–69–C–3629.

—**Chaney and Hope, Inc.**, Addison, Tex. $2,-619,582. Construction of firing ranges, numerous buildings and roads at Fort Carson, Colo. Army Engineer District, Omaha, Neb. DA–CA45–69–C–0080.

—**Stevens Manufacturing Co.**, Ebensburg, Pa. $1,690,861. Semi-trailer vans (M313) and semi-trailer chassis (M295A). Army Tank Automotive Command, Warren, Mich. DA–AE07–69–C–4894.

—**Hoffman Electronics Corp.**, El Monte, Calif. $1,788,000. Design and engineering development models of AN/TRN radio beacon and ancillary items. Army Electronics Command, Fort Monmouth, N.J. DA–AB07–69–C–0320.

—**Martin Marietta Corp.**, Orlando, Fla. $17,-737,500. Ground support equipment for Pershing missiles for the Federal Republic of Germany. Orlando and Paoli, Pa. Army Missile Command, Huntsville, Ala. DA–AH01–69–C–1534.

—**Dondlinger and Sons Construction Co., Inc.**, Wichita, Kan. $1,092,000. Construction of two 3-story airmen dormitories at McConnell AFB, Wichita, Ka. Army Engineer District, Kansas City, Mo. DA–CA41–69–C–0065.

—**General Motors Corp.**, Indianapolis, Ind. $1,100,000. Evaluation, redesign, fabrication and test of the automatic loader for the XM70 combat tank. Army Tank Automotive Command, Warren, Mich. DA–20–113 AMC–08843(T).

19—**Texas Instruments, Inc.**, Dallas, Tex. $2,-305,983 (contract modification). AN/ASQ–127 night vision surveillance systems. Army Mobility Equipment Research and Development Center, Fort Belvoir, Va. DA–AK02–68–C–0308.

—**Olin Mathieson Chemical Corp.**, La Porte, Ind. $1,793,550. Load, assemble and pack 20mm cartridges. Frankford Arsenal, Philadelphia, Pa. DA–AA22–69–C–0227.

—**Bell Aerospace Corp.**, Fort Worth, Tex. $1,158,115. Hydraulic servo cylinders for OH-58A helicopters. Hurst, Tex. Army Aviation Systems Command, St. Louis, Mo. DA–AJ01–68–A–0118.

—**Hayes-Albion Corp.**, Albion, Mich. $1,036,-160. Metal parts for 81mm projectiles. Albion and Hillsdale, Mich. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA–AA09–69–C–0309.

20—**Melpar**, Falls Church, Va. $5,790,031. High frequency ground radio systems for Iran. Army Electronics Command, Fort Monmouth, N.J. DA–AB07–69–C–0289.

—**Bell Aerospace Corp.**, Fort Worth, Tex. $3,549,000. Modification kits for UH-1 helicopters. Hurst, Tex. Army Aviation Materiel Command, St. Louis, Mo. DA–AJ01–69–A–0314.

—**Pace Corp.**, Memphis, Tenn. $1,826,754 (contract modification). M127A1 illumination signals. Memphis and Camden, Ark. Picatinny Arsenal, Dover, N.J. DA–AA21–69–C–0519.

—**Hercules Engines, Inc.**, Canton, Ohio. $1,550,468. Multi-fuel engine assemblies for 5-ton trucks. Army Tank Automotive Command, Warren, Mich. DA–AE07–69–C–4394.

—**ITT Gilfillan, Inc.**, Van Nuys, Calif. $1,-400,000. AN/TPN-18 radar sets and ancillary items. Army Electronics Command, Fort Monmouth, N.J. DA–AB07–69–C–0288.

—**General Motors Corp.**, Indianapolis, Ind. $1,115,301. T-63 engines for light observation helicopters. Army Aviation Systems Command, St. Louis, Mo. DA–AJ01–69–C–1333.

—**Thiokol Chemical Corp.**, Bristol, Pa. $3,-215,156. Load, assemble and pack medium and large caliber ammunition. Marshall, Tex. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA–11–173–AMC–00200(A).

—**Harvey Aluminum Co.**, Torrence, Calif. $3,004,954. Load, assemble and pack medium caliber ammunition. Milan, Tenn. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA–11–173–AMC–00520(A).

—**National Gypsum Co.**, Buffalo, N.Y. $2,-676,545. Load, assemble and pack medium

and large caliber ammunition. Parsons, Kan. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA-11-173-AMC-00095(A).

—**Sperry Rand Corp.**, New York, N.Y. $2,-105,794. Load, assemble and pack large caliber ammunition. Shreveport, La. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA-11-173-AMC-00080(A).

21—**Caterpillar Tractor Co.**, Peoria, Ill. $5,647-439 (contract modification). Tractors, repair parts and service manuals. Peoria and Aurora, Ill. Army Mobility Equipment Command, St. Louis, Mo. DA-AK01-68-C-8147.

—**R.A. Heintz Construction Co.**, Portland, Ore. $3,997,008. Relocation of 10.4 miles of state highway near Eureka, Mont. Army Engineer District, Seattle, Wash. DA-CW67-69-C-0039.

—**Bauer Dredging Co., Inc.**, Port Lavaca, Tex. $1,172,648. Dredging of shoal material in the Houston ship channel. Army Engineer District, Galveston, Tex. DA-CW64-69-C-0075.

—**Non-Profit Institution of Cornell University**, Ithaca, N.Y. $7,317,900 (contract modification). Continuation of research in the Interdisciplinary Materials Research Program. Defense Supply Service, Washington, D.C. DA-HC15-67-C-0214.

—**Non-Profit Institution of the University of Pennsylvania**, Philadelphia, Pa. $6,894,-300 (contract modification). Research in the Interdisciplinary Materials Research Program. Defense Supply Service, Washington, D.C. DA-HC15-67-C-0215.

—**Non-Profit Institution of the University of Illinois**, Urbana, Ill. $6,234,400 (contract modification). Research in the Interdisciplinary Materials Research Program. Defense Supply Service, Washington, DC. DA-HC15-67-C-0221.

22—**Atlas Corp. and H.C. Smith Construction Co., DBA Global Associates**, Oakland Calif. $60,195,595. Logistic support for Kwajalein Missile Range, Marshall Islands. Safeguard System Command, Huntsville, Ala. DA-HC60-70-C-0001.

—**Bell Aerospace Corp.**, Fort Worth, Tex. $1,921,045. Main rotor blades for UH-1 helicopters. Hurst, Tex. Army Aviation Systems Command, St. Louis, Mo. DA-AJ01-69-A-0314.

—**White Motor Corp.**, Lansing, Mich. $1,313,-749. 2½-ton truck gasoline engines with accessories. Army Tank Automotive Command, Warren, Mich. DA-AE07-69-C-3443.

—**General Electric Co.**, Burlington, Vt. $1,-068,346 (contract modification). Various quantities of line item spare parts for Vulcan XM163 and XM167 weapons systems. Army Procurement Agency, New York, N.Y. DA-AG25-69-C-0403.

23—**J.J. Altman and Co.**, East St. Louis, Ill. $7,667,865. Construction of headquarters building #4 at the Military Airlift Command, Scott AFB, Belleville, Ill. Army Engineer District, Chicago, Ill. DA-CA23-69-C-0091.

—**TRW Inc.**, Redondo Beach, Calif. $3,000,-000. Classified electronics equipment. Army Electronics Command, Fort Monmouth, N.J.

—**Bell Aerospace Corp.**, Fort Worth, Tex. $2,531,108. Main rotor blades for UH-1 helicopters. Hurst, Tex. Army Aviation Systems, St. Louis, Mo. DA-AJ01-69-A-0314.

—**Texas Instruments, Inc.**, Dallas, Tex. $1,-735,000. Classified equipment. Dallas and Sherman, Tex. Army Mobility Equipment Research and Development Center, Fort Belvoir, Va. DA-AK02-69-C-0603.

—**Sheidow Bronze Corp.**, Kingwood, W. Va. $1,376,320. Bronze grave markers for veteran's graves. Office of the Chief of Support Services, Washington, D.C. DA-49-056-SS-(70)-391.

—**Texas Instruments, Inc.**, Dallas, Tex. $1,-214,010. Classified work. Dallas and Sherman, Tex. Army Mobility Equipment Research and Development Center, Fort Belvoir, Va. DA-AK02-68-C-0541.

—**Bell Aerospace Corp.**, Fort Worth, Tex. $1,199,877. Tail booms for UH-1 helicopters. Hurst, Tex. Army Aviation Systems Command, St. Louis, Mo. DA-AJ01-69-A-0314.

26—**Automatic Switch Co.**, Florham Park, N.J. $1,945,333. Production of automatic switching units and spare parts for electrical updating of Minuteman Wing III, Minot AFB, N.D. Ballistic Missile Construction Office, Army Corp of Engineers, Norton AFB, Calif. DA-CA13-69-C-0010.

27—**Murphy Brothers, Inc.**, Spokane, Wash. $3,982,593. Relocation of 10½ miles of forest development road, Libby Dam Project, Mont. Army Engineer District, Seattle, Wa. DA-CW67-69-C-0043.

28—**Browning Construction Co.**, San Antonio, Tex. $1,239,700. Construction of clinical laboratory at Brooks AFB, Tex. Army Engineer District, Fort Worth, Tex. DA-CA63-69-C-0163.

—**Chrysler Corp.**, Marysville, Mich. $1,089,-820. Model 75M-1407 and HT 361-579 engines for V100 and M113 armored personnel carriers. Army Tank Automotive Command, Warren, Mich. DA-AE07-60-C-2605.

—**Cutler-Hammer, Inc.**, Deer Park, N.Y. $2,-581,510. AN/PPS-5 radar sets and ancillary items. Army Electronics Command, Fort Monmouth, N.J. DA-AB07-68-C-0432.

—**Northrop Corp.**, Anaheim, Calif. $4,244,-594. Warheads (WDU-4A/A) for 2.75 rockets. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA-AA09-69-C-0308.

—**Varo, Inc.**, Garland, Tex. $1,012,330. Metascope aessemblies (AN/PAS-6) and metascope viewers (SV-43/UAS-6) for night vision viewing. Army Electronics Command, Fort Monmouth, N.J. DA-AB07-69-C-0340.

—**Uniroyal, Inc.**, New York, N.Y. $7,149,772 (contract modification). Production, loading, assembling and packing ammunition. Joliet Army Ammunition Plant, Joliet, Ill. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA-11-173-AMC-00062(A).

—**Chamberlain Mfg. Corp.**, Elmhurst, Ill. $1,353,200 (contract modification). 152mm high explosive projectiles. Waterloo, Iowa. Army Procurement Agency, Chicago, Ill. DA-AA21-68-C-0691.

—**Electrospace Corp.**, Glen Cove, N.Y. $2,-706,116. AN/TVS-2 night vision sights. Army Electronics Command, Fort Monmouth, N.J. DA-AB07-69-C-0329.

29—**A. O. Smith Corp.**, Chicago, Ill. $8,151,300. Metal parts for 750-pound bombs. Bellmead, Tex., Birmingham, Ala. and Milwaukee, Wis. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA-AA09-69-C-0398.

—**Olin Mathieson Chemical Corp.**, New York, N.Y. $1,932,218. Manufacture, load, assemble and pack propellants. Charlestown, Ind. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA-11-173-AMC-00097(A).

—**Supreme Products Corp.**, Chicago, Ill. $1,071,600. Metal parts for 750-pound bomb tail fuzes. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA-AA09-60-C-0074.

—**Bell & Howell Co.**, Chicago, Ill. $1,018,-019. Metal parts for time fuzes for 81mm illuminating projectiles. Evanston, Ill. Army Ammunition Procurement and Supply Agency, Joliet, Ill. DA-AA09-69-C-0334.

—**Chrysler Corp.**, Centerline, Mich. $7,742,-500. System engineering management for M60A1E2 tank. Army Weapons Command, Rock Island Arsenal, Ill. DA-AF03-69-C-0087.

—**Hughes Aircraft Co.**, Culver City, Calif. $7,500,000. Limited production of Iroquois night fighter and night tracker (INFANT) systems. Army Electronics Command, Fort Monmouth, N.J. DA-AB07-69-C-0348.

—**CONDEC Corp.**, Old Greenwich, Conn. $6,-210,030. Pershing erector launchers. Army Missile Command, Redstone, Ala. DA-AH01-69-C-1817.

—**Honeywell, Inc.**, Tampa, Fla. $1,765,422. 425 lightweight, full, duplex voice multiplexers (TD660/G). Philadelphia Procurement Div., Army Electronics Command. DA-AB05-69-C-1036.

—**General Motors Corp.**, Detroit, Mich. $2,-475,689. Diesel engines (6V53) for M113 vehicle series. Army Tank Automotive Command, Warren, Mich. DA-AEO7-69-C-4362.

—**J. A. Guy, Inc.**, Dublin, Ohio. $2,224,600. Construction of office and shop wings, Wright-Patterson AFB, Ohio. Army Engineer District, Louisville, Ky. DA-CA27-69-C-0043.

—**AVCO Corp.**, Stratford, Conn. $1,166,532. (contract modification). T55-L-11 turbine engines for CH-47C. Army Aviation Systems Command, St. Louis, Mo. DA-AJ01-68-C-1853.

DEPARTMENT OF THE NAVY

1—**Bendix Corp.**, Teterboro, N.J. $8,540,289. Inertial components for Poseidon guidance systems. Naval Strategic Systems Project Office, Washington, D.C. N00030-69-C-0081.

—**Litton Systems, Inc.**, Culver City, Calif. $113,900,000. Construction of new-type multi-purpose amphibious warfare ships (LHA). Ingalls Shipbuilding Div., Litton Systems, Pascagoula, Miss. Naval Ship Systems Command, Washington, D.C. N00024-69-C-0283.

2—**Stewart and Stevenson Services, Inc.**, Houston, Tex. $2,082,190. Procurement of 2000 KW generator plants for the U.S. Naval Construction Battalion Center, Davisville, R.I. Naval Facilities Engineering Command, through U.S. Naval Construction Battalion Center, Davisville, R.I. N62578-69-C-0069.

—**Singer-General Precision, Inc.**, Glendale, Calif. $1,560,909. Conversion of Mk 48 torpedo modification kits. Naval Ordnance Systems Command, Washington, D.C. N00017-68-C-1218.

—**Lockheed Missiles and Space Co.**, Sunnyvale, Calif. $1,255,000. Conversion of FBM weapons training equipment at Dam Neck, Va., and Charleton, S.C., to Poseidon (C-3) training capability. Naval Strategic Systems Project Office, Washington, D.C. N00030-69-C-0013.

—**K. Chavis General Contractor, Inc.**, Pensacola, Fla. $1,277,700. Construction of an industrial waste disposal facility at the Naval Air Station, Pensacola, Fla. Naval Facilities Engineering Command, through Southeast Division, Charleston, S.C. N62467-67-C-0422.

—**Comprehensive Designers Inc.**, Culver City, Calif. $2,426,091. Engineering, drafting and technical writing services in support of the Point Hueneme Naval Ship Missile Systems Engineering Station programs. Naval Purchasing Office, Los Angeles, Calif. N00123-69-C-091.

5—**Sydney Construction Co., Inc.**, Brookline, Mass. $2,885,000. Construction of 150 units of family housing at the Naval Air Station, South Weymouth, Mass. Naval Facilities Engineering Command, through Northeast Division, Boston, Mass. N62464-68-C-0002.

—**Aerojet-General Corp.**, Sacramento, Calif. $1,776,828. Production of Mk 56 Mod O rocket motors. Naval Ordnance Systems Command, Washington, D.C. N00017-69-C-2212.

—**Western Gear Corp.**, Lynwood, Calif. $1,-136,576. Drive train kits for SATS weapons loaders. Naval Air Engineering Center, Philadelphia, Pa. N00156-69-C-1646.

—**Pennsylvania State University**, University Park, Pa. $1,112,145. Research on Mk 48 torpedoes. Naval Ordnance Systems Command, Washington, D.C. NOw 65-0123-d.

6—**RCA Defense Electronic Products**, Camden, N.J. $23,190,516. Manufacture of direction finder and countermeasures equipment. Naval Electronic Systems Command, Washington, D.C. N00039-69-C-2576.

—**Newport News Shipbuilding and Dry Dock Co.**, Newport News, Va. $4,009,725 (contract modification). Furnishing of additional material and services required to prepare for the overhaul, repair, alteration and refueling of the USS Enterprise (CVAN 65). Naval Ship Systems Command, Washington, D.C. P011N00024-68-C-0293.

—**Texas Instruments Inc.**, Dallas, Tex. $1,-510,080. Spare parts for the RA-5C aircraft ANI AAS-21 infrared system. Naval Aviation Supply Office, Philadephia, Pa. N00383-69-A-1801-0010.

—**Texas Instruments Inc.**, Dallas, Tex. $1,-377,108. Spare parts for A-7 aircraft radar (AN/APQ 126). Naval Aviation Supply Office, Philadelphia, Pa. N00383-67-A-2001-0669.

—**Southwestern Portland Cement Co.**, Los Angeles, Calif. $1,253,400. General purpose cement. Victorville, Calif. Naval Purchas-

ing Office, Los Angeles, Calif. N00123-69-C-2209.

—**Raytheon Co.**, Lowell, Mass. $5,367,598 (Increase in authorization limitation). Chapparal missile guidance and control groups for the Army. Naval Air Systems Command, Washington, D.C. N00019-69-C-0200.

—**General Electric Co.**, Utica, N.Y. $3,515,-625. Airborne data processing systems. Naval Air Systems Command, Washington, D.C. N00019-68-C-0254.

—**General Electric Co.**, Utica, N.Y. $1,914,-943 (increase of limitation authorization). Chapparal missile guidance and control groups for the Army. Naval Air Systems Command, Washington, D.C. N00019-69-C-0199.

—**Sanders Associates, Inc.**, Nashua, N.H. $1,164,587 (increase of authorization limitation). Classified electronic equipment. Naval Air Systems Command, Washington, D.C. N00019-69-C-0331.

7—**Sewart Seacraft**, Berwick, La. $2,007,332. Thirteen 50-foot fast patrol craft (PCF). Naval Ships Systems Command, Washington, D.C. N00024-69-C-0302.

—**Sunstrand Corp.**, Rockford, Ill. $1,329,146 (contract modification). Constant speed drives for installation in A-7 aircraft. Naval Air Systems Command, Washington, D.C. N00019-68-C-0088.

—**Electrospace Corp.**, Glen Cove, N.Y. $1,-047-006. Chaff dispensers. Naval Air Systems Command, Wasbington, D.C. N00019-69-C-0596.

8—**Philco-Ford Corp.**, Fort Washington, Pa. $37,642,970. Maintenance, repair and operation of equipment and facilities for naval activities in I Corps area, Vietnam. Naval Facilities Engineering Command, Washington, D.C. N00024-69-C-0021.

—**Admiral Systems Corp.**, Chicago, Ill. $4,-513,915. AN/ARC 51 radio sets used on various aircraft. Naval Aviation Supply Office, Philadelphia, Pa. N00383-69-C-2089.

—**Walsh and Co.**, Anchorage, Alaska. $2,-356,958. Construction of station hospital, Adak, Alaska. Naval Facilities Engineering Command, through Northwest Division, Seattle, Wash. N62476-69-C-0030.

—**Southeastern Construction Co.**, Charlotte, N.C. $1,909,700. Construction of a recruit processing facility, Naval Training Center, Orlando, Fla. Naval Facilities Engineering Command, Washington, D.C. N62467-67-C-0270.

—**Raytheon Co.**, Portsmouth, R.I. $1,600,000. Modification to sonar equipments and supporting engineering services. Naval Ship Systems Command, Washington, D.C. N00024-69-C-1294.

—**LTV Electro Systems Inc.**, Salt Lake City, Utah. Test monitor control equipment for ground to air communication equipment. Naval Supply Center, Oakland, Calif. N00228-69-C-1518.

—**Kilgore Corp.**, Toone, Tenn. $1,470,000. Aircraft parachute flares. Naval Ships Parts Control Center, Mechanicsburg, Pa. N00104-69-C-0152.

9—**Litcom Systems, Inc.**, Melville, N.Y. $2,-429,150. Manufacture of eight OMEGA navigational transmitting sets. Naval Electronics Systems Command, Washington, D.C. N00039-69-C-0560.

12—**McDonnell Douglas Corp.**, Long Beach, Calif. $26,833,980. TA-4J aircraft. N00019-69-C-0390. $21,598,084 (contract modification). A-4H and TA-4H aircraft. N00019-67-C-0090. $9,017,980 (contract modification). A-4K and TA-4K aircraft. N00019-67-C-0170. Work will be done at Long Beach and Palmdale, Calif. Naval Air Systems Command, Washington, D.C.

—**LTV Aerospace Corp.**, Dallas, Tex. $2,381,-841 (contract modification). Services and materials to incorporate improvement changes on RF-8A aircraft. Naval Air Systems Command, Washington, D.C. N00019-68-C-0130.

—**Spedcor Electronics, Inc.**, Glendale, N.Y. $1,896,216. Classified electromechanical beacons. Naval Ship Systems Command, Washington, D.C. N00024-69-C-5469.

—**Boeing Co.**, Morton, Pa. $1,595,395 (contract modification). CH-46D helicopters. Naval Air Systems Command, Washington, D.C. N00019-68-C-0391.

13—**Honeywell, Inc.**, Minneapolis, Minn. $9,-263,790 (contract modification). Components for Rockeye II bombs. Naval Air Systems Command, Washington, D.C. N00019-69-C-0163.

—**Hughes Aircraft Co.**, Culver City, Calif. $5,400,000 (contract modification). Increase of authorization limitation for Pheonix guided missiles. Tuscon, Ariz., and Culver City. Naval Air Systems Command, Washington, D.C. N00019-68-C-0296.

—**Jenkins and Boller, Inc.**, Waukegan, Ill. $1,143,000. Construction of addition to a recruit building, Naval Training Center, Great Lakes, Ill. Naval Facilities Engineering Command, Washington, D.C. N62465-67-C-0384.

—**Galloway Co.**, Baldwin Park, Calif. $1,-404,610. Mk 115, Mod. O, high explosive bombs. Naval Air Systems Command, Washington, D.C. N00019-69-C-0608.

16—**Sperry Rand Corp.**, St. Paul, Minn. $2,-401,347. Seven shipboard logistical computer systems. Naval Ship Systems Command, Washington, D.C. N00024-69-C-1308.

—**Reflectone Inc.**, Stanford, Conn. $1,530,555. Radar operator training complex (15-G-16) and radar target simulator device (15-G-16A). Naval Training Device Center, Orlando, Fla. N61339-69-C-0249.

19—**American Machine and Foundry Co.**, York, Pa. $4,921,520. Mk 82 Mod 1 bomb bodies. Naval Ships Parts Control Center, Mechanicsburg, Pa. N00104-69-C-0341.

—**United States Steel Corp.**, Pittsburgh, Pa. $3,741,600. Mk 82 Mod 1 bomb bodies. Mc-Keesport, Pa. Naval Ships Parts Control Center, Mechanicsburgh, Pa. N00104-69-C-0340.

—**Borg-Warner Corp.**, Chicago, Ill. $1,803,-072. Mk 82 Mod 1 bomb bodies. Naval Ships Parts Control Center, Mechanicsburg, Pa. N00104-69-C-0343.

—**Intercontinental Manufacturing Co.**, Garland, Tex. $1,875,600. Mk 82 Mod 1 bomb bodies. Naval Ships Parts Control Center, Mechanicsburg, Pa. N00104-69-C-0343.

21—**Raytheon Co.**, Sudbury, Mass. $9,888,888. Definitization of technical changes and procurement of MK-3 Poseidon electronics assemblies. Naval Strategic Systems Project Office, Washington, D.C. N00030-66-C-0159 Mod. P010.

—**Reid and Hope**, Suffolk, Va. $1,522,029. Construction of bachelor enlisted quarters, Norfolk Naval Shipyard, Portsmouth, Va. Naval Facilities Engineering Command, Washington, D.C. N62470-68-C-0528.

22—**Hughes Aircraft Co.**, Culver City, Calif. $9,600,000 (contract modification). Incremental funding for Phoenix missile program. Naval Air Systems Command, Washington, D.C. N00019-67-C-0240.

—**Boeing Co.**, Morton, Pa. $1,311,007. De-ice blankets for H-46 helicopters. Naval Aviation Supply Office, Philadelphia, Pa. N00383-68-A-5601-0736.

23—**KDI Precision Products Inc.**, Cincinnati, Ohio. $1,234,000. Mk 51, Mod 5 fuzes for three-inch, 50 caliber projectiles. Naval Ships Parts Control Center, Mechaniscburg, Pa. N00104-69-C-0348.

26—**United Aircraft Corp.**, Stratford, Conn. $11,540,290. HH-3E helicopters for the Air Force. Naval Air Systems Command, Washington, D.C. N00019-69-C-0355.

—**Litton Systems, Inc.**, Woodland Hills, Calif. $2,965,846. Carrier Aircraft Inertial Navigation Systems (CAINS). Naval Air Systems Command, Washington, D.C. N00019-69-C-0582.

—**McDonnell Douglas Corp.**, St. Louis, Mo. $1,700,000. Parts and equipment for F-4C and RF-4C aircraft for the Navy and Air Force. Naval Air Systems Command, Washington, D.C. N00019-68-C-0495 Mod P090.

—**American Air Filter Co., Inc.**, St. Louis, Mo. $1,004,999. Trailer-mounted air conditioning units for maintenance and preflight checkout. Naval Air Systems Command, Washington, D.C. N00019-69-C-0632.

—**Radiation Systems Inc.**, McLean, Va. $2,-940,545. Design, development, fabrication and testing of components, developmental and prototype guidance sections, and associated support equipment for Shrike (AGM-45A-8) anti-radiation missiles. Naval Purchasing Office, Los Angeles, Calif. N00123-69-C-2115.

—**General Steel Tank Co.**, Reidsville, N.C. $1,310,400. Construction of four high-capacity amphibious assault fuel systems. Headquarters, U.S. Marine Corp, Washington, D.C. N00027-69-C-0180.

27—**Sperry Rand Corp.**, Great Neck, N.Y. $2,-500,000 (contract modification). Modernization of Mk 119 (Mods 0 and 5) computers. Naval Ordnance Systems Command, Washington, D.C. N00017-69-C-2325.

—**R.D. Lambert and Son, Inc.**, Chesapeake Va. $2,094,560. Construction of and aircraft overhaul and repair facility, Naval Air Rework Facility, Naval Air Station, Norfolk, Va. Naval Facilities Engineering Command, Washington, D.C. N62470-68-C-0486.

—**Collins Radio Co.**, Cedar Rapids, Iowa. $2,261,641. AN/ARC-51 radio sets for aircraft. Naval Aviation Supply Office, Pbiladelphia, Pa. N00383-69-C-2093.

—**Dillingham Corp., DBA Hawaiian Dredging and Construction Co., and Al Johnson Construction Co.**, Honolulu, Hawaii. $1,865,900. Improvement of Drydock No. 2, Naval Shipyard, Pearl Harbor, Hawaii. Naval Facilities Engineereing Command, Washington, D.C. N62471-69-C-0333.

—**Electronic Specialty Co.**, Thomaston, Conn. $1,338,050. 25 electric motor generator sets and associated control equipment. Naval Ship Systems Command, Washington, D.C. N00024-69-C-5327.

—**Sperry Rand Corp.**, St. Paul, Minn. $1,-044,651. Computers and associated repair parts. Naval Ship Systems command, Washington, D.C. N00024-69-C-1309.

—**Gibbs Manufacturing and Research Co.**, Janesville, Wis. $1,000,399. Production of ignition separation assemblies (Mk 3-1) for Asroc missiles. Naval Ordnance Systems Command, Washington, D.C. N00017-69-C-1437.

28—**Grumman Aircraft Engineering Corp.**, Bethpage, N.Y. $1,146,000. Building maintenance at Naval Weapons Industrial Reserve Plant at Bethpage. Naval Air Systems Command, Washington, D.C. N00019-69-C-9048.

—**Northrop Corp.**, Newbury Park, Calif. $4,456,171 (contract modification). MQM-74A target drones. Naval Air Systems Command, Washington, D.C. N00019-69-C-0306.

—**Kaman Corp.**, Bloomfield, Conn. $1,682,000 (contract modification). Parts and equipment for conversion of UH-2A/B helicopters to UH-2C twin-engine configuration. Naval Air Systems Command, Washington, D.C. N00019-69-C-0066.

—**Hazeltine Corp.**, Little Neck, N.Y. $1,165-750. Classified electronic equipment for the Air Force. Naval Air Systems Command, Washington, D.C. N00019-69-C-0557.

29—**McInnis Brothers, Inc.**, Minden, La $3,720,-047. Construction of medical facility at Barksdale AFB, La. Naval Facilities Engineering Command, Washington, D.C. N62468-67-C-0336.

—**Farmers Tool & Supply Corp.**, Denver, Colo. $2,537,435. Wings and roller on assemblies for Sidewinder and Chaparrall missiles. Naval Ordnance Station, Indian Head, Md. N00174-69-C-0627.

—**H. W. Stanfield Construction Corp.** and **S. L. Haehn, Inc.** (joint venture), San Diego, Calif. $2,069,971. Construction of barracks at Naval Training Center, San Diego. Naval Facilities Engineering Command. N62473-68-C-0122.

—**Pyrotector, Inc.**, Hingham, Mass. $1,111,-532. Fire-suppression equipment and related data for Marine Corps amphibious vessels. Naval Ship Systems Command, Washington, D.C. N00024-69-C-5483.

DEPARTMENT OF THE AIR FORCE

1—**Sperry Rand Corp.**, St. Paul, Minn. $1,-000,000 Design and development of a Minuteman weapon systems computer. Space and Missile Systems Organization, (AFSC), Los Angeles, Calif. F04701-69-C-0111.

—**Sperry Rand Corp.**, Salt Lake City, Utah. $1,700,000. Preproduction planning and long lead time materials for production of YQU-22A aircraft. Aeronautical Systems Division, (AFSC), Wright-Patterson AFB, Ohio. F33657-69-C-1148.

—**Textron, Inc.**, Grants Pass, Ore. $1,205,-400. Production of multiple ejector racks

for A-7D and F-4 aircraft. Warner Robins Air Materiel Area, (AFLC), Robins AFB, Ga. F09603-69-C-3320.

—**Hughes Aircraft Co.**, Fullerton, Calif. $1,000,000. Prototype testing of a wide band array radar. Rome Air Development Center, (AFSC), Griffis AFB, N.Y. F30602-69-C-0309.

2—**McDonnell Douglas Corp.**, St. Louis, Mo. $3,133,900. Modification of RF-4C aircraft. Robertson, Mo. Odgen Air Materiel Area, (AFLC), Hill AFB, Utah. F34601-68-A-2919.

6—**General Electric Co.**, Burlington, Vt. $1,-243,000. Production of ammunition storage drums. Armament Development and Test Center, (AFSC), Eglin AFB, Fla. F08635-69-C-0014.

7—**Goodyear Aerospace Corp.**, Akron, Ohio. $2,050,000 Production of radar bombing systems. Aeronautical Systems Division, (AFSC), Wright-Patterson AFB, Ohio. F33615-69-C-1569.

12—**Lasko Metal Products, Inc.**, Chester, Pa. $3,648,879. Production of fin assemblies for 750-pound bombs. Pittston and West Chester, Pa. Ogden Air Materiel Area, (AFLC), Hill AFB, Utah. F42600-69-C-3171.

—**Kollsman Instrument Corp.**, Syosset, N.Y. $2,355,000. Aerospace ground equipment (AN/USQ-28) for RC-135 aircraft. Aeronautical Systems Division, (AFSC), Wright-Patterson AFB, Ohio. F33657-69-C-0860.

13—**Partner Industries of America, Inc.**, Chicago, Ill. $1,150,205. 71 fire trucks and spare parts. Appleton, Wis. Warner Robins Air Materiel Area, (AFLC) Robins AFB, Ga. F09603-69-C-3372.

16—**Hughes Aircraft Corp.**, Culver City, Calif. $1,499,500. Modification of Falcon (AIM-4D) missiles and related aerospace ground equipment. Aeronautical Systems Division, (AFSC), Wright-Patterson AFB, Ohio. F33657-69-C-0589.

19—**Modulux, Inc.**, Newark, Calif. $1,084,440 (contract modification). Production of modular relocatable buildings. Warner Robins Air Materiel Area, (AFLC), Robins AFB, Ga. F09603-69-C-1645-P004.

20—**Lockheed Aircraft Corp.**, Sunnyvale, Calif. $1,616,000. Prototype development and testing of a space vehicle navigation and guidance improvement system. Space and Missile Systems Organization, (AFSC), Los Angeles, Calif. F04701-69-C-0150.

—**Lockheed Aircraft Corp.**, Marietta, Ga. $1,016,543. Full-scale fatigue test program of C-130B through E series aircraft. Warner Robins Air Materiel Area, (AFLC), Robins AFB, Ga. F09603-68-C-2956.

21—**Chromalloy American Corp.**, New York, N.Y. $2,358,449. Repair and coating of J-57 and J-75 engine turbine nozzle guide vanes. West Nyack, N.Y. San Antonio Air Materiel Area, (AFLC) Kelly AFB, Tex. F34601-68-A-2991.

27—**General Electric Co.**, West Lynn, Mass. $5,300,000. CY 69 component improvement program for T-64 engine series. Aeronautical Systems Division, (AFSC), Wright-Patterson AFB, Ohio. F33657-69-C-0385-P001.

29—**Cable Communication System, Inc.**, Cambridge, Mass. $1,642,107. Engineering and furnishing submarine cable system between Sitka and Lena Point, Alaska. Cambridge and Portsmouth, N.H. Air Force Systems Command, Andrews AFB, Washington, D.C. F45633-69-C-0087.

—**Hughes Aircraft Co.**, Canoga Park Calif. $3,119,900. Production of components for Falcon missiles. Aeronautical Systems Div., (AFSC), Wright-Patterson AFB, Ohio. F33657-69-C-1014.

—**Cessna Aircraft Co.**, Wichita, Kan. $11,632-000. Procurement of O-2A aircraft, aerospace ground equipment, spare parts, and data. Aeronautical Systems Div., (AFSC), Wright-Patterson AFB, Ohio. F33657-68-C-PZ26).

OFF-SHORE PROCUREMENT

29—**Canadian Commercial Corp.**, Litton Systems, Ltd., Rexdale, Ontario. $1,204,046. Procurement of weapons release control systems (ANASQ-91) for F-4D/E aircraft. Aeronautical Systems Div., (AFSC), Wright-Patterson AFB, Ohio. F33657-69-C-0634-POO5.

Navy Lets Contract for New LHA Ships

The Navy has awarded a contract for construction of a new class ship to the Ingalls Shipbuilding Division of Litton Systems, Pascagoula, Miss. The $113.9 million contract provides for the construction of one multi-purpose amphibious warfare ship (LHA) and a long lead time for the second and third ships. A total of nine LHAs has been called for in the multi-year, billion dollar proposal. Delivery of the first ship is expected in spring 1973.

Faster and more versatile than any amphibious warfare ships now in the Fleet, the LHA will perform missions now requiring four different types. As large as an Essex-type carrier, the LHA combines the features of the amphibious assault ship (LPH), the amphibious transport dock (LPD), the amphibious cargo ship (LKA), and the dock landing ship (LSD). The LHA will be capable of transporting and putting ashore an entire Marine battalion landing team, with their combat equipment.

Incorporated into the ships will be new safety, propulsion and command facilities. A fire detection system will sense the presence of products of combustion in addition to temperature. The steam propulsion plant will be automated, with a remote location central control system and built-in logic circuitry to handle engineering casualties automatically.

In addition, command and control facilities will include semi-automated communications systems, and all-weather traffic and approach control facilities are provided for the helicopters and boats. A special acclimatizing gym will provide either arctic or tropic weather conditioning for the Marine battalion. Medical facilities include three operating rooms and a 300-patient sick bay.

The proposed nine LHAs represent considerable cost savings, according to the Navy. Some 21 specialized amphibious warfare ships will be deleted from the Navy's five-year plan, and three Boxer-type LPHs and some older amphibious ships will be retired when the LHAs join the Fleet.

The project manager for the LHA program is Captain R. F. Wilkinson of the Naval Ships Systems Command, Washington, D.C.

Navy's New Gunpowder Reduces Weapon Wear

A new type of gunpowder called NACO (Navy Cool), which burns at temperatures 300 degrees cooler than standard gunpowder, has been developed by the Naval Ordnance Station, Indian Head, Md.

As a result of the reduced heat, shipboard gun wear has been cut in half. Since the liners inside the barrels of naval guns must be replaced periodically because of the erosion caused largely by heat, the development of NACO means that combatant ships can stay on the firing line for longer periods.

Another important advantage of NACO is the elimination of most of the muzzle blast and smoke usually associated with gunfire. This feature diminishes the damage caused by gunfire on delicate shipboard equipment, especially electronic components.

The virtual absence of flash and smoke provides the Navy, for the first time, with a universal propellant suitable for round-the-clock operations. Ships will no longer need to use two kinds of gunpowder to prevent detection: a smokeless-type for daytime missions and a flashless type for nighttime use. NACO will serve both purposes.

NACO propellant is now used by the Navy's five-inch .54 caliber guns. Development is also underway for use of the new propellant on other Navy weapons, including the 16-inch guns of the battleship USS New Jersey.

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DSA Establishes Control Point for Quality Assurance To Service Foreign Buyers

Foreign governments, international organizations and foreign military contractors, authorized by the U.S. Government to procure military supplies in the United States, now have a single point of contact for quality assurance.

According to a recently instituted system, the Defense Contract Administration Services Region (DCASR) New York, 60 Hudson St., New York, N. Y. 10013, a field activity of the Defense Supply Agency, has been designated as the central control point for quality assurance services on direct foreign military procurements.

In the past the foreign buying activities have had to deal with several offices of the Military Services for administration of contracts.

Under the new central control point concept, the foreign representative gets in touch with DCASR New York as soon as a contract has been made with industry. DCASR New York then places the quality assurance for the work with the DCAS regional office responsible for the plant involved, or with a Military Service if the plant is under one of the Services for contract administration.

When the quality assurance service is completed, the DCAS region or the military office involved reports the time and cost of the service to DCASR New York. DCASR New York then bills the foreign government for the cost of the service. Payment for the goods is handled between the foreign government and the American contractor.

There are exceptions to the new central control point program, however. Canadian purchases in the United States and direct procurements for which a Military Department is the executive agent will continue under the terms of seperate agreements. NATO'S Maintenance and Supply Agency will deal directly with the activity responsible for the supplier.

The Defense Supply Agency expects the central control point concept to eliminate confusion and facilitate the quality assurance of military items produced for foreign buyers.

The concept is the latest addition of unified service in the administration of contracts.

Army Calls for "Waterwings" for Combat Troops

The Army Combat Developments Command (CDC), Fort Belvoir, Va., is seeking a 10-ounce inflatable flotation device capable of supporting 250 pounds—the equivalent of a soldier and his equipment—for use in combat.

The flotation device is in answer to needs from the field, and is seen as invaluable for troops engaged in water operations, such as those in Vietnam's Mekong Delta. The device, according to the CDC Letter Requirement, would be worn with combat gear, be lightweight, compact, reuseable and reinflatable. In addition, it would make it impossible for the wearer's head to go under water.

The proposal calls for ease of inflation/deflation and packaging. The device would be constructed in two or three bladder-like compartments, repairable or replaceable at the squad level.

Ideally, the flotation device would allow the soldier in the water to fire his weapon, and several of the devices would be joinable to form a raft to further serve soldiers in water operations.

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